Dedication

To Sue, my wife, for all her support and love over the years.

Crime Scene Photography

Third Edition

Edward M. Robinson
Forensic Science Department
The George Washington University
Washington DC, United States



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Biography

EDWARD (TED) ROBINSON



Edward (Ted) Robinson began a career with the Arlington County (VA) Police Department in 1971. He was promoted to Police Agent, ACPD's name for a CSI, and then promoted to Master Police Officer, ACPD's top level CSI. In 1996, After 25 years, he retired from the ACPD and immediately began working as a civilian supervisor with the Baltimore County Police Department's Forensic Services Section (Crime Lab), supervising a shift of mostly civilian CSI and training all new hires.

During this period, he was trained at the Virginia Forensic Science Academy in Richmond, Virginia, in 1988, and was certified as a Senior Crime Scene Analyst by the IAI (CSCSA) in 1990. In 1991, Ted completed the Master of Forensic Science degree at The George Washington University (GWU).

In 2000, Ted was hired as an Associate Professor at GWU to create the CSI concentration for the MFS degree. As part of this work, Ted wrote the book *Crime Scene Photography* for Academic Press in 2007 to serve as the text for his Photography in the Forensic Sciences course. The second edition was published in 2010 and the third edition will be published in August 2016.

ROBERT C. SANDERS



Robert C. Sanders retired in 2016 from the Wisconsin State Crime Laboratory in Wausau, Wisconsin. Robert has 36 years of experience as a Forensic Photographer/Imaging Specialist. This includes 24 years of experience in a state crime laboratory and 12 years of experience in the US Army Crime Laboratory System where he completed his 2-year Forensic Photography course. Prior to being transferred to the Army Crime Laboratory, he was assigned to Fort Stewart as an Army CID Agent. As a Forensic Imaging Specialist, his duties included, but were not limited to, crime scene processing, latent print photography, IR photography, UV photography, LASER photography, image processing, providing imaging training, and the examination of photographic and video evidence. He has testified as an expert witness in the field of Forensic Imaging in both Federal and Local Courts.

KING BROWN



Mr. Brown holds a Master's degree in Criminal Justice and is an IAI-certified Senior Crime Scene Analyst, Certified Forensic Photographer & Certified Latent Print Examiner, and an EPIC-Certified Evidence Photographer. He is the Crime Scene Supervisor for the West Palm Beach (Florida) Police Department, 2011 President of the Florida Division of the IAI, Chairman of the Forensic Photography Certification Board for the state of Florida, Crime Scene Investigation Chair for the IAI Standing Committee, Recipient of the Good of the Association Award, and has been in the field of forensic science for 24 years. Mr. Brown is the President of the Gold Coast Forensic Association and is an Adjunct Professor at Brevard Community College in the Crime Scene Technology Associates Degree Program, IPTM-University of North Florida, Orlando, and an instructor for The Taylor Group teaching Crime Scene Photography, Basic & Advanced Crime Scene Search & Recovery and Advanced Latent Fingerprints. King has also been a lecturer at the IAI Training Conferences since 1996.



DAWN WATKINS

Ms. Watkins holds a Master's Degree in Criminal Justice and is a Certified Latent Print Examiner, Certified Forensic Photographer, and a Certified Senior Crime Scene Analyst with the IAI and an EPIC-Certified Evidence Photographer. Ms. Watkins is on the IAI Latent Print Identification Standing Committee and Recipient of the Good of the Association Award. She has been in the field of forensics for 35 years, formally with the Federal Bureau of Investigations, Washington DC. She is currently the Senior Latent Print Examiner/Crime Scene Investigator with the Palm Beach Gardens Police Department in Florida. Ms. Watkins serves on the Educational Board of the Gold Coast Forensic Association and is an instructor for IPTM-University of North Florida, Orlando & The Taylor Group teaching Advanced Latent Fingerprints. Dawn has been a lecturer at the IAI Training Conferences since 1996.



MARC HACKETT

Master Police Officer/Corporal Hackett has received a BS in law enforcement from University of Maryland at College Park. He started his law enforcement career while in college as an auxiliary with the University of Maryland Police Department and was hired by Arlington County Police Department prior to his graduation in 1986.

He worked in the patrol section on permanent midnight shift for over 19 years. While in patrol, he was promoted to Corporal (crime scene technician) in November of 1994. He is a graduate of the Virginia Forensic Science Academy—51st Session. For the last 9 years, he has been teaching Crime Scene Photography and Basic Crime Scene Collection at the Northern Virginia Criminal Justice Academy. He also has taught Crime Scene Photography and Total Station and has graded practical scenes at the Virginia Forensic Academy. He has held a position as the Northern Director of the Virginia Forensic Science Academy Alumni Association, and currently he is the second Vice President. He is also an IAI-Certified Crime Scene Analyst.

He is currently assigned to the Criminal Investigation Section of the Arlington Police department working in the Crime Scene Unit. He is responsible for major scenes, research and development of new equipment and techniques, forensic challenging scenes, and training new crime scene technicians.

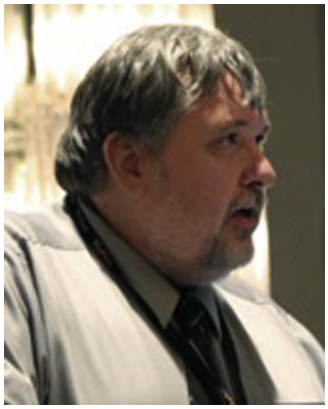
He has been trained in Crash Investigation by the Maryland State Police and IPTM. He has had over 500 h in crash investigation training to include Crash Photography, Total Station, Motorcycle Crashes, and Pedestrians and Human Factors. As part of his duties in the Crime Scene Unit is also fatal and serious crash investigation.



MIKE BERRY

Mike is considered the world's leading authority in underwater criminal investigations based on his 35 years of active experience in this field. He is an author, lecturer, dive consultant, business owner, and the only Master Underwater Criminal Investigator and Master Public Safety Diver Instructor Trainer in the world. Mike is currently the Virginia State Police Search and Recovery Team coordinator and the founder and CEO of UCI (Underwater Criminal Investigators), which is an award-winning training company that specializes in providing underwater criminal investigations training to police, fire, rescue, and military dive teams from around the world. Mike has been recognized by the Federal Bureau of Investigations (FBI), Secrete Service, the Naval Criminal Investigative Service (NCIS), countless law enforcement agencies at home and abroad, and has been awarded the Virginia State Police Superintendent's "Award of Merit" for his dive leadership and service.

TONY HALLETT



Tony Hallett is an entrepreneur, researcher, and writer. After serving in law enforcement, industrial security, and emergency medical services for 15 years, Hallett became the Assistant Director of a research and technology transfer center operated by the University of Pittsburgh and Carnegie Mellon University. In the late 1980s, he launched the first of what would be several companies focused on the integration of technology into first responder operations. Hallett's current ventures serve the forensic science, public safety, healthcare, energy, and unmanned systems markets.

JOHN "CALVIN" GAZIANO



John "Calvin" Gaziano has been a police officer for almost 22 years, a crime scene investigator for 14 years, and is currently employed with a police department in the San Francisco Bay Area. He is a certified bloodstain pattern analyst and a certified senior crime scene analyst with the International Association for Identification (IAI). In addition, he is the owner of a forensic science company (Leuko-Sight Forensics) where he teaches a certified 40-h bloodstain pattern analysis course and assists police agencies with their more serious cases. He has a Bachelor of Science degree from the University of California, Berkeley, and a Master of Science degree from San Jose State University. He is currently finishing a second Master's degree in Forensic Science. His website is leuko-sightforensics.com. E-mail: jgaziano@leuko-sightforensics.com.

DR. AGNIESZKA ROGALSKA

Dr. Agnieszka Rogalska is the Deputy Medical Examiner of the Dane County Medical Examiner's Office in Madison, WI. She is a Forensic Pathologist who has practiced as a fellow in the Hennepin County Medical Examiner's Office and as an Assistant Medical Examiner in Milwaukee, WI. Dr. Rogalska serves on the National Association of Medical Examiner's Position Paper Committee and the Wisconsin Hospital Emergency Preparedness Program Statewide Expert Panel.

TAMMY RUSSELL



Master Police Officer Tammy Russell, BS, NRP, is a police officer, flight paramedic, and SWAT paramedic for Fairfax County Police Department in Virginia. Her law enforcement career has spanned 17 years, the last 11 of which have been in her current role with the Helicopter Division under the Operational Support Bureau. She received her Bachelor of Science degree in Psychology from Bridgewater College and became a nationally registered paramedic through The George Washington University and Northern Virginia Community College. MPO Russell operates as a senior member of the Helicopter Division, where she has trained numerous new flight officer/paramedics. She and her flight crews have been responsible for locating hundreds of criminals and lost and/or endangered people, as well as providing life-saving care and medical evacuation for critically injured patients. Her primary duties are to the citizens of Fairfax County; however, the Division serves, in a mutual aid capacity, as an aerial platform to approximately 15 other jurisdictions in the National Capital Region and beyond. MPO Russell utilizes the most advanced search techniques and forward looking infrared (FLIR) and camera technologies to locate target individuals and vehicles. These skills were recognized by the Airborne Law Enforcement Association in 2008 when she and her crew received an International FLIR Vision Award. She routinely provides informational demonstrations

and lectures about law enforcement and helicopter operations to members of the public and was recently an invited speaker at Virginia Congresswoman Barbara Comstock's 10th Congressional District Women in Leadership Program. E-mail: tammy.russell@fairfaxcounty.gov.



DOUGLAS E. MIDDLEBROOKS, PHD

Douglas E. Middlebrooks, PhD, is a Tactical Flight Officer with the Fairfax County Police Department Helicopter Division and a paramedic with the city of Fredericksburg Fire Department. With more than 20 years of combined government service in the US Army National Guard, law enforcement, and fire and rescue, he has worked diligently and proudly to serve the public. His career in law enforcement includes assignments as a uniform patrol officer, investigator, and flight officer/paramedic. As an investigator, he led a task force to stem the diversion of prescription drugs and authored a government report titled Prescription Fraud in Fairfax County: Summary and Recommendations. He is a certified flight paramedic through BCCTPC and certified in Pediatric and Neonatal Critical Care Transport through UMBC. He holds a PhD in Organization and Management, MBA in International Business, and an MA in International Relations. E-mail: douglas.middlebrooks@fairfaxcounty.gov.



KEITH A. DOBULER

Keith A. Dobuler is the Photographic Services Manager at the Fairfax County Police Department, the largest local jurisdiction law enforcement agency in the Commonwealth of Virginia. Keith has utilized his photographic and imaging skills within the context of law enforcement for the past 24 years. He received his Bachelor's degree in professional and technical photography from the Rochester Institute of Technology, and prior to joining the FCPD in 2002, he served as a crime scene investigator with a law enforcement agency in Florida. His areas of specialization include aerial photography and the transition from analog to digital image acquisition and archiving. He is a certified law enforcement instructor, has published his work in several periodicals and books, and is a coauthor of the book *Fairfax County Police Department 75th Anniversary, A Pictorial History 1940–2015*. Keith is a member of the International Association for Identification and the Virginia Homicide Investigator's Association. E-mail: keith.dobuler@fairfaxcounty.gov.



VICTOR W. WEEDN, MD, JD

Victor W. Weedn, MD, JD, is a Professor and Chair of the Department of Forensic Sciences at The George Washington University. He is a forensic pathologist and attorney. He has practiced as a medical examiner performing autopsies and testifying in Texas, Pennsylvania, New Jersey, and Maryland, as well as with the Department of Defense in the Armed Forces Medical Examiner Office, where he created the US military's DNA identification program. He serves on the Medicolegal Death Investigation subcommittee of the National Commission of Forensic Sciences and on the Disaster Victim Identification subcommittee of the National Institute of Standards and Technology's Organization of Scientific Area Committees. He is a past President of the American Academy of Forensic Sciences.

JACKIE SMITHSON



Jackie Smithson is a police officer and Crime Scene Investigator for the Broken Arrow Oklahoma Police Department. He holds a Master's Degree in criminal justice and is a Certified Crime Scene Investigator through the International Association for Identification. Smithson has over 18 years of law enforcement experience with 13 years of forensic experience in the areas of crime scene investigation/reconstruction, fingerprint development and comparison, and forensic video analysis. Smithson is currently the Immediate Past President/Chairman of the Board for the Oklahoma Division of the International Association for Identification. Additionally Smithson has served has as the Membership Chairman for the Association for Crime Scene Reconstruction and is currently an instructor at a Northeastern State University (Oklahoma) where he teaches forensic courses.

JONATHYN PRIEST



Jonathyn Priest is a 32-year veteran of the Denver Police Department in Colorado, retiring as the commander of the Major Crimes Section. He has over 27 years of experience investigating thousands of criminal incidents of violence during his tenure as a detective, supervisor, and command officer. He is currently a forensic analyst and partner with Bevel, Gardner and Associates, Inc.

Jon is a court-recognized expert in Arizona, Colorado, California, and Texas district courts and US federal courts in bloodstain pattern analysis, crime scene and shooting incident reconstruction, death investigation, and major case management. In addition to criminal incident testimony, he appears and consults in civil cases related to death investigations, officer-involved critical incidents, and major case management.

He has an extensive background in the area of death investigation and officer-involved critical incident investigations. Jon developed the Denver Police Department's investigation protocol and training curriculums in the area of death investigation, officer-involved critical incidents, cold case investigations, and interview and interrogation.

TINA YOUNG



Tina Young began her postsecondary education at The Ohio State University and later graduated cum laude with a Bachelor of Science in Criminal Justice and a Master of Forensic Sciences from National University in San Diego, California. She also completed hundreds of hours of forensic science and law enforcement–related training.

In July, 2007, Professor Young became a certified bloodstain pattern examiner through the International Association for Identification and was recertified in 2012. She was previously employed as a crime scene specialist with the National City, California, Police Department and an evidence technician with the Chula Vista, California, Police Department.

Currently, Tina Young is a Professor and Academics Coordinator in the Administration of Justice Department at Grossmont College in El Cajon, California. Additionally, she provides forensic case consultation and forensic training to public agencies and private entities. She is a court-appointed expert in bloodstain pattern analysis and forensic technology, appointed by Judge Henry Hall of the Los Angeles County Superior Court.

Professor Young published *Crime Scene Investigation—The Forensic Technician's Field Manual*, 2010, Pearson Prentice Hall, and *A Photographic Comparison of Luminol, Fluorescein, and Bluestar* in the November/December 2006 issue of the *Journal of Forensic Identification*.

She is a member of the International Association for Identification, the International Association of Bloodstain Pattern Analysts, the California State Division of the International Association for Identification, the Southern California Association of Fingerprint Officers, the Rocky Mountain Association of Bloodstain Pattern Analysts, the California Association of Administration of Justice Educators, and is a member and Grossmont College chapter advisor for the American Criminal Justice Association/Lambda Alpha Epsilon.

Professor Young volunteers to provide forensic science training to disadvantaged youth, including children in the foster care system, K-12 math and science teachers, patrol officers in law enforcement, and workshops at national conferences. In July, 2008, she was awarded the *Partner in Law Enforcement Award* by the National City Police Department for her forensic science-related volunteer work.



DAVID WITZKE

With more than 25 years of AFIS and forensic digital imaging experience, David Witzke (better known as Ski) is considered to be one of the foremost experts in forensic digital imaging technologies. Ski is an Associate Member of the International Association for Identification (IAI) as well as the European and regional divisions of the IAI, is a member of the Canadian Identification Society (CIS), and is an associate member of the European Network of Forensic Science Institutes Fingerprint Working Group (ENFSI FWG). Ski has been invited to speak at hundreds of regional, national, and international IAI conferences; AFIS user group meetings; and the ENFSI FWG meetings in Split, Croatia; Taormina, Italy; and Barcelona, Spain. Ski was also the guest instructor of the *Digital Imaging of Evidentiary Photography* training program at the FBI Academy in Quantico, Virginia, for more than 7 years, and was the instructor for the *Forensic Digital Image Processing* program at the British Columbia Institute of Technology (BCIT) in Vancouver, BC, for more than 6 years. He also provided digital imaging training for the Automatic Fingerprint Recognition systems (AFR) Consortium at police agencies throughout the United Kingdom, and for the Federal Department of Justice and Police AFIS/DNA Services in Berne, Switzerland. Ski is a contributing writer for three well-known forensic books: ***Crime Scene Photography*** (Second Edition, Published 2010 by Academic Press), ***Introduction to Crime Scene Photography*** (Published 2012 by Academic Press), and ***Footwear, The Missed Evidence*** (Third Edition, Published 2013 by Staggs Publishing). (***Crime Scene Photography*** has been chosen by the IAI certification committees for the Certified Crime Scene Investigator (CCSI) Certification Test, the Certified Crime Scene Analyst (CCSA) Certification Test, the Certified Senior Crime Scene Analyst (CSCSA) Certification Test, and the Forensic Photography Certification Test.)

Foreword

The world of law enforcement is forever changing; the process of gathering evidence has never been more complex—or more interesting. Few would argue that one of the most important tools in the evidence-gathering process is a camera. In the right hand, photographs can forever capture what is viewed through the viewfinder.

Most importantly, proper techniques in both camera use and crime scene documentation can also reveal important information that the investigator did not know what was important at the time.

On July 31, 1996 near St. Joseph, MI, Berrien County Sheriff deputies investigated the tragic shooting of a 4-year old with a shotgun. It appeared to be a terrible accident. Still, the investigating deputy took more than three rolls of film at the scene. Information later obtained suggested it had not been an accident. The photographs taken by the deputy were submitted to the state police crime lab and were then used to reconstruct the scene of the shooting at the location it occurred. It was determined at that time it could not have happened as the mother suggested. She then confessed to killing her own child and is now serving a life term without parole in Ypsilanti, Michigan.

Had it not been for the use of proper camera techniques and proper scene documentation, the child's mother may have never been held accountable for this most heinous act.

While cameras used in the proper manner have always been a useful tool, they have never been more useful and versatile as the many forms of digital cameras available today. From cell phone cameras to point-and-shoot cameras to the most advanced DSLR cameras, the ability to instantly record and capture events is shared by nearly everyone. As a result, the perception by many is that taking pictures with a digital camera is much simpler than in the "film days."

In some ways that is true, as digital provides advantages like not being restricted to the number of shots on a roll of film, and the ability for a "do-over" if a review of the image reveals bad focus or exposure. Those of us that have evolved from the film days have experienced the horror of getting back prints and finding the film was not loaded properly, or the flash was not synced properly, or the exposures were wrong. And while digital has helped to reduce many of those unrecoverable errors, it has introduced new challenges that the investigator must be aware of and learn how to overcome.

Police officers, lab technicians, and others tasked with the duty to investigate and collect evidence at a crime or crash scene receive a great deal of training in most aspects of their profession. As important as photography is, however, training in this discipline is typically very limited and sometimes not even available. There are very few books, classes, or other resources dedicated to this discipline.

Persons interested in just learning the basics, or improving their ability to use a digital camera, or even those aspiring to become a competent forensic photographer, will find this book invaluable. Topics range from the most basic camera principles, to sophisticated techniques used to document trace evidence, to processing techniques that follow guidelines for admissibility, and to a study of court cases that have impacted photography in law enforcement. The author has provided an organized and logical approach to the discipline of crime scene photography that will prove to be a valuable resource for investigators at all levels.

Learning objectives at the beginning of every chapter help to quickly identify what the reader can expect to learn in that chapter. Discussion questions are provided at the end of each chapter, and suggested practical exercises are listed that will help the motivated reader fine-tune their skills. Throughout the text are useful "rules of thumb" that many will find to be a great tool. In each case, the rule of thumb is explained, and variables are often detailed.

While many textbooks provide instruction on the "best way" to apply specific techniques, throughout this book the author encourages the reader to apply the suggested techniques but also explains that there is rarely one method that is the "right way." Instead, readers are encouraged to experiment with their equipment under various conditions and learn what works best for them. This book provides a baseline that allows each reader to test and validate their skills in their own environment.

In 2014, the second edition of this book was recommended reading by the Forensic Photography Certification Board of the International Association for Identification (IAI) for anyone interested in obtaining certification in this field. In my review of this third edition, I find the author has done an exemplary job of updating examples, references, and techniques needed by those working in or interested in this field, to maintain a level of proficiency in this rapidly evolving world of digital imaging.

D. Eric Johnson, CEP, CFPH
First Lieutenant, Michigan State Police (retired)
Chair, Forensic Photography Certification Board,
International Association for Identification

Acknowledgments

It is becoming a bit embarrassing to have just my name on the cover of this book. The number of contributors has grown considerably. And, without their additions to this text, many would agree the value of the book itself would be greatly diminished. I'd also like to express my thanks to Joe Matvay for passing on many corrections noticed in the second edition.

Returning to the scene of the crime are both David (Ski) Witzke and Robert C. Sanders. Ski's two chapters on Digital Imaging Technologies and Digital Image Processing are probably worthy of standing on their own as a separate book, and I'm delighted Ski has agreed to provide his chapters for my book yet again. I have no such promise for the fourth edition. Bob's chapter on the History of Forensic Imaging keeps getting better and growing. Having a firm foundation is always necessary for any sturdy edifice, and this goes for books as well.

King Watson and Dawn Watson are probably best known for their traveling show at many recent IAI conferences with presentations and workshops on Luminol, BlueStar, and UV/IR photography techniques and equipment. When I looked for someone to do a substantial rewrite to my chapter on Ultraviolet, Infrared, and Fluorescence, they graciously accepted the challenge and made that chapter quite a bit better. In the Appendix, you will also still be able to see their contribution on High Dynamic Range photography.

Tina Young's work on Darkfield Illumination can again be found in the Appendix. In this edition, two current students of hers, Julia Underwood and Kimberly Sid Weber, assisted her with images related to Darkfield Illumination and Black Shield photography.

Speaking of students, I have had many of my students contribute images in this edition. These were D. Schweizer, B. Reilly, L. Yockel, Dale Rio for many images, V. Hart, K. Mentore, M. Simms, E. Fellers, L. Pachucki, Rebecca Shaw, K. Kinsie, S. Dickson, M. Eaves, P. Nelson, B. Pridgen, D. Maslanka, J. Collins, C. McGillivary, S. Keppel, J. Veltri, K. Martin, G. Jenkins, M. Ward, M. Towers, R. Thompson, D. Sediq, D. Goodwyn, A. Lowcher, L. Pacheco, J. Wreh, S. Reeve, T. Beecher, S. Halter, N. Shah, C. Sikorski, T. Nelson, D. Foote, S. Lingsch, J. Sinex, S. Dziejma, M. Hendricks, V. Hart, S. Kingsbury, E. Moon, M. Hashemi, J. Kirk, T. Black, E. Spiegel, J. Labiosa, S. Byrnes, L. Grant, K. Caulfield, M. Geniuk, J. Wilson, H. Butters, C. Perletti, K. Athenas, S. Roeske, A. Amihere, K. Brockhohn, T. Busse, E. Murray, S. Wise, N. Oliver, and M. Scott. Two students worked on updating the Legal Case Citations appearing in this edition: J. Dalh and D. Wines.

As always, I need to thank Ron Taniwaki, with Nikon Professional Services, for many images appearing in this book, and Nikon, Inc. for supplying the Nikon cameras, lenses, and flash units I used throughout this book.

As will quickly be noticed by all who are familiar with either of the first two editions, chapter, "Special Photography Situations", Special Photographic Situations, has been greatly expanded. I wanted this edition to have specialized sections on areas of crime scene photography where I do not consider myself an expert. So, I reached out to friends and professionals.

The previous section on Accident Photography has been retitled Vehicular Crash Photography and has now been rewritten by Master Police Officer Marc Hackett of the Arlington County Police Department. I thought I needed a professional currently in the field to make this section more relevant.

And, the section on Aerial Photography should be written by professionals in the field, so I contacted the Fairfax County Police Helicopter Division and asked if they would provide a major overhaul of the previous section on Aerial Photography. With the police department command's approval, Master Police Officers Douglas Middlebrooks and Tammy Russell, along with FCPD's Photographic Services Manager, Keith Dobuler all agreed to take on the rewrite. Their combined work improved this section enormously.

The Underwater Photography section was rewritten by Master Public Safety Dive Instructor Trainer, Mike Berry, who is currently the Virginia State Police Search and Recovery Team Coordinator. Mike convinced me he knew a couple of things about underwater photography that I did not already know!

To the sections of chapter, "Special Photography Situations" which appeared in the second edition, four new sections have been added: Autopsy Photography, Bloodstain Pattern Photography, the photography from Drones, and Firearms Trajectory Photography.

For an expert on autopsies, I only needed to walk down the hall to Dr. Vincent Weedn's office, the Chair of the Forensic Science Department at The George Washington University. As an MD, he is a forensic pathologist and has served as a medical examiner in several states. He serves on the Medicolegal Death Investigation subcommittee of the National Commission of Forensic Sciences and on the Disaster Victim Identification subcommittee of the National Institute of Standards and Technology's Organization of Scientific Area Committees. Collaborating on the Autopsy Photography section is also Agnieszka Rogalska, Deputy Medical Examiner for the **Dane** County Medical Examiner's Office, Wisconsin.

The Bloodstain Pattern Photography is a new section written by John Calvin Gaziano, a law enforcement officer of 22 years, who currently also has his own company, Leuko-Sight Forensics, where he teaches a certified 40-h Bloodstain Pattern Analysis course.

The new section on Drone photography was written by Tony Hallet and Jackie Smithson. With a background in law enforcement, Tony founded the company, Unmanned Response, Inc., and his other ventures serve the forensic science, public safety, health care, and unmanned systems markets. Jackie Smithson has worked for the Broken Arrow Oklahoma PD for 17 years and is past President of the Oklahoma Division of the IAI.

Last, but not least, Jon Priest has provided a section on shooting reconstruction photography. He is a 32-year veteran of the Denver PD in Colorado, retiring as the commander of the Major Crimes Section. He is currently a partner and forensic analyst with Bevel, Gardner and Associates, Inc.

I am sure that the new chapter, "Special Photography Situations" will quickly be viewed as one of the strongest chapters of the third edition!

Introduction

This textbook is designed for two principal photography student types. One group is the **student in an academic setting**. Students are expected to acquire a solid grasp of the theories and concepts of their various courses. This is the **K**nowledge point of the "KSAs" frequently required by employers. Students in an academic setting normally are expected to also learn the aspects of photography that have their foundation in physics and optics. But, to make students competitive in the real world when applying for their first jobs, it is also important to have them acquire the **S**kills and **A**bilities which are the remainder of the sought after triad of "KSAs." Current students will have to be able to capture successful images at their future jobs, so this text hopefully provides them the knowledge to create crime scene images which will ultimately withstand challenges in court.

A second student type is the **current practitioner** already working within various law enforcement agencies. Techniques to get the job done are what they look for. These students will hopefully learn the basics of crime scene photography, and improve their skill set by reading this text, and eventually become recognized within their agencies as the go-to person when quality images are required.

This marriage of theory and practice is a fundamental aspect of this textbook.

Now, I am extremely excited to be able to produce this third edition. I have tried to update each of my chapters from the second edition, and this text has additional material not originally in previous editions. There are many new images in this edition.

This edition is much longer than the second edition. Besides updates and additions to each previous chapter, chapter, "Special Photography Situations" now has four new sections: Autopsy Photography, Bloodstain Pattern Photography, Drone Photography, and Shooting Reconstruction Photography. Now, for almost every photographic need a crime scene photographer would have at various crimes has been covered in this text. These four new sections, as well as three previous sections from the third edition, were all written by experts in the field. I wanted the reader to have the very best information available in this new edition. With this same idea in mind, I asked Dawn Watkins and King Brown to help me rewrite the chapter, "Ultraviolet, Infrared, and Fluorescence". They have covered the country with their many presentations on these topics at various IAI conferences and many other venues.

To avoid making this text ungainly, deletions have had to been made. All the court cites from the first two editions have been removed, and chapter, "Legal Issues Related to Photographs and Digital Images" now only features court cases since the last edition. The legal citations from the first two editions are still available to the reader: they have been added to the Companion Website all readers have access to (Available at, http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646). Also in this Companion Website you can find the material from the previous chapter, "Basic Exposure (Non-Flash) Concepts" dealing with the history of diffraction. Although I find this history to be extremely interesting, some readers just wishing to improve their current photography skills do not need this information. But for those who felt it helped explain the need to select a different f/stop for examination quality photographs other than an f/22 which maximizes the depth of field of an image, this information is still available to you in the Companion Website.

When both the IAI's Crime Scene Certification Board and the Forensic Photography Certification Board chose the previous editions as required reading for each of their certifications, then, and only then, did I know my book had been accepted by those who mattered. It is hoped that this third edition proves equally qualified.

Edward (Ted) Robinson

CHAPTER 1

History of Forensic Imaging

Robert C. Sanders
Forensic Scientist, Retired

Chapter Outline

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Key Terms

Alternate Light Source
Ambrotype
Barrier Filter
Calotype
Carte-de-Visite
Camera Obscura
Chain of Custody
Composite Photographic
Daguerreotype
Data Migration
Drone
Dye-Sensitizing
Exciter Light Source
Fair and Accurate Photograph
Fast Fourier Transfer (FFT) Filter
Gel or Gelatin Filter
Ghost Photographs
Glass Filter
Hillotype
Image
Imaging
Infrared (IR)
IR Photograph
Optical Watermark
Orthochromatic Film
Panchromatic Film
Panoramic Camera
Photogrammetry
Prosumer
QTVR
Representation
Reverse Projection Photogrammetry
Spirit Photographs
Stokes' Law
Superimposition Technology
Telecine Machine
Tintype
UV Fluorescence
Wet Plate Process

MY INSPIRATION

A common misconception is that the history of our profession is useful only to historians, teachers, students, and trivia buffs. This misconception is reenforced by the daily pressures of the workload that, sometimes, has to be accomplished with inadequate staff, outdated equipment, limited funding, lack of recognition of photography as a profession, and limited training.

Several years ago, two things prompted me to put together a presentation on the history of forensic photography that I have presented at several International Association for Identification (IAI) conferences, which in turn, evolved into this chapter. First, it became apparent this was a weak area for applicants taking the written component of the IAI Forensic Photography Certification Test. Second was the following comment that Ron Smith (retired forensic scientist and President of Ron Smith and Associates) made to me: "If you do not know the history of your profession, you are doomed to repeat its mistakes."

As I began putting this presentation together, I soon learned that I was gaining a better insight into how the evolution from film to digital photography was changing; how I do my own job, just as previous evolutionary changes in photographic technology had affected my predecessors. One pattern that I observed was that the profits in the consumer photographic market were a significant factor in the survival of a technology. As a result, when my laboratory director asked me what signs he could look for to determine when we would have to convert from film to digital, I told him the following: When you go into the local discount stores and see a dramatic reduction in film for sale to consumers, you better have the funding to convert to digital photography, and when there is no film for sale for consumers, you need to have already completed the conversion. It also made me more aware that the students in an evidence technician class had to learn the same basic photographic skills with their digital cameras that I learned in the 1970s with film-based cameras.

THE PRACTICAL VALUE

I hope that this background will help to explain why a knowledge of the history of forensic photography can be useful in several practical ways to anyone working in any capacity in forensic/law enforcement **Imaging**. First, you will have the knowledge needed to refute a mistaken argument that a procedure or equipment that you use is new and novel, and therefore subject to a Frye hearing to determine admissibility. Just because it is new and novel to a defense lawyer or an individual forensic photographer does not necessary mean that it is new and novel to the forensic

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science community as a whole. Second, if you are going to be taking a certification test, most written certification tests include questions about the history of your profession. Third, it can help you to anticipate the likely impact and how to adapt to changes or evolutions in technology. Fourth, this knowledge can help you to be better prepared to advise lawyers, managers, and others on forensic imaging issues. Fifth, keep in mind that the law enforcement market is a relatively small percentage of the overall still photography market as compared to commercial photography, the consumer market, the newspaper and magazine publishing industry, portrait/wedding studios, and mini-labs. From this perspective, it makes sense to keep up to date with what happens at the combined Photo Marketing Association (PMA) and Consumer Electronics Show (CES) shows, where most of the new imaging products are announced, except for specialized equipment used only by law enforcement or other small niche markets. Other useful trade shows and educational conferences include, but are not limited to the Annual Educational Conference of the IAI, the Annual Educational Conference of the American Academy of Forensic Scientists (AAFS), and the Law Enforcement and Emergency Services Video Association International, Inc. (LEVA).

The important part is that as you read through the following history, you should also be looking for patterns in the evolution of the technology and the markets for this technology. In the early days of the wet plate, the market for photographic equipment and supplies was limited to mainly professionals. However, even at that time the consumer played an indirect role based on what they were to pay for portrait photographs. There is a valid argument that Kodak changed all that when it marketed roll film cameras to the general public and provided the processing and printing. In today's digital photography world, there are three markets: amateur or consumer, **Prosumer**, and professional.

So much for the overview of the framework; now we move on to the main course, the history of forensic imaging.

THE HISTORY

The history of forensic imaging begins with the **Camera Obscura**, the first pinhole camera. Although there may be a conflict among authors as to who is the first to describe the camera obscura, it is most likely the Arab scholar Hassan bin al Haitham who wrote about it in 1038 (Davis, 1995, p. 2; Frizot, 1998, p. 18). It is common knowledge that these early pinhole cameras were used by scientists to observe the sun and by artists to make sketches. Two others who are credited by some authors as the first to describe the camera obscura are Roger Bacon in 1267 and Leonardo da Vinci in 1490 (Davis, 1995, p. 2; Frizot, 1998, p. 17).

In reference to the early history of imaging, there are two potential reasons for differences in the date that an author lists for a specific historical event. First, each event has a possibility of four dates associated with it: when the research began, when the research results were completed, when the results were patented, and when the results of the research were first published or publicly announced.

There were three more evolutions in the design of the camera obscura that were necessary before it would have all the basic functional parts of early photographic cameras (see Fig. 1.1). In 1550, Girolamo Cardano added a lens to the design of the camera obscura. It is reported that he used the word "lens" because the color of the glass lens reminded him of brown lentils that were used in Italian soup (Hedgecoe, 1980, p. 18). The second evolution, the addition of lenses and curved mirrors to produce an upright **Image**, was accomplished in 1558 by Giovanni Battista della Porta (Davis, 1995, p. 2). However, this was not published until 1588 (Frizot, 1998, p. 18). The third evolution, the invention of a diaphragm, was believed to have been made by Daniele Barbaro in 1568 (Hedgecoe, 1980, p. 18).

The early discoveries that ultimately led to the development of flexible silver halide–based film were also progressing slowly. In 1614, Angelo Sala observed that sunlight turned silver nitrate black. However, he did not know why, and there was no record of him recognizing the significance of this observation (Davis, 1995, p. 3). Later in 1725, Johann Heinrich Schulze proved that some silver salts were darkened by exposure to light (Davis, 1995, p. 3) (1727 according to Hedgecoe, 1980, p. 20; Frizot, 1998, p. 18). In 1737, Jean Hellot was reported to have used a photographic process to make secret writings visible by exposure to light. Hellot may have been the first one to use the word "photography," which means writing with light (Hedgecoe, 1980, p. 20). In 1777, Carl Wilhelm Scheele discovered that silver chloride was reduced to blackened silver by exposure to light, and that ammonia dissolved the silver chloride without affecting the blackened silver. However, there was no recording of Scheele's trying to use this discovery to record photographic images (Davis, 1995, p. 3; Frizot, 1998, p. 19). The first known attempt by Thomas Wedgwood to use a photographic process to take a photograph with a camera obscura occurred in 1795. The attempt failed due to a combination of underexposure and Wedgwood's inability to fix the image (Davis, 1995, p. 4; Hedgecoe, 1980, p. 20).

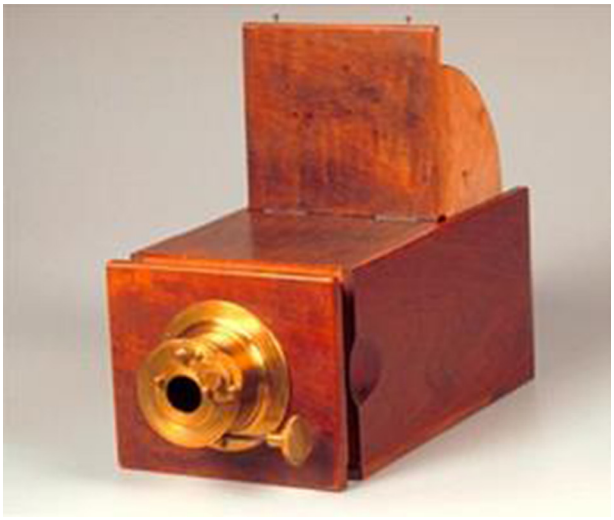


FIGURE 1.1
This is an example an 1840s portable camera obscura with an adjustable diagraph.
Photograph Courtesy of George Eastman House. © George Eastman House.

Some photographic concepts date back to paintings. The term panorama was first used to refer to paintings with a wide field of view that were either mounted or painted on the walls of a circular shaped building. The first record of such a building was the "circular panorama building" that was built in Leicester Square in London by Robert Barker in 1792. Barker had previously received a patent for this concept in 1787 (Woeste, http://www.graphics.com/article-old/history-panoramic-image-creation and Wells et al., 2007).

In 1800, Sir William Herschel made a discovery that would later be extremely important to law enforcement photographers. Herschel discovered the invisible **Infrared** region by a simple experiment. He used a beam splitter to split out a white light source into individual colors when he placed a thermometer next to the red end where there was no visible color of light. This is how he discovered the infrared region of the electromagnetic spectrum (Scott, 1969, vol. 2, p. 79).

In 1816, Joseph Niépce began his photography experiments (Davis, 1995, p. 4; Newhall, 1964, pp. 13 and 32; Frizot, 1998, p. 19). In 1819, while Niépce was conducting his experiments, John Herschel discovered that hydrosulfite of soda dissolves silver salts (Newhall, 1964, pp. 13 and 32; and Frizot, 1998, p. 19). This was the missing link needed to fix a developed photographic image. However, it was not until several years later in 1826 when Niépce successfully made the first known photograph (see Fig. 1.2). For this reason, he has been credited as being the inventor of photography (Davis, 1995, p. 4; Newhall, 1964, pp. 20–21; Frizot, 1998, p. 19).



FIGURE 1.2
On the left is a photograph of Joseph Niepce. On the right is the first photograph that he took in 1826. © Brian Ratty, Photo Seminars.

There were several important developments in 1822. Mathematicians were working on what later evolved into **Photogrammetry**. One such early work was General Jean-Victor Poncelet treatise on projective geometry that was published in 1822 (Buchanan, p. 82, http://elib.uni-stuttgart.de/opus/volltexte/2010/5142/pdf/bu14.pdf). The fresnel lens that is used in every digital single lens reflex (DSLR) viewfinder was also invented in France in this year (Rockwell, http://www.kenrockwell.com/tech/dxo/optics-pro.htm). Another French contribution was made by Joseph Fourier who developed the "Fourier series, the basis of Fourier transforms, Fast Fourier Transforms (FFTs), modulation transfer functions (MTFs) used to measure and describe optics, and the basis of the discrete cosine transform (DCT) which is the basis of all JPG and MPEG images today" (Rockwell, http://www.kenrockwell.com/tech/dxo/optics-pro.htm). For most crime scene photographers, this may seem like useless history. However, in the laboratory the FFT filter is used in image processing software to enhance latent prints developed on a surface with a repetitive pattern.

It was also about this time that the first discovery critical to the development of motion pictures and video recording was made. In 1824, Peter Mark Roget wrote a paper on the persistence of vision, which was credited with leading to the following inventions that preceded motion pictures and video: Ayrton's thaumatrope, Stampfer's stroboscope, Faraday's wheel, and the flip book (Cheshire, 1979, p. 18).

There is no known record of Niépce's technology being commercially successful. However, in 1829 Louis Daguerre formed a partnership with Joseph Niépce and, after Joseph's death, with Isidore Niépce (Frizot, 1998, p. 21). In 1839, Daguerre's invention, the **Daguerreotype**, was announced by Arago. The daguerreotype used a silver nitrite light–sensitive emulsion that was developed with mercury vapor and fixed with a strong salt solution to produce a positive photographic image (Davis, 1995, p. 5). The daguerreotype was the first commercially successful photographic process. Later in this chapter, three photographic processes that replaced the daguerreotype will be discussed. In addition to their historical value, these processes are important for the modern forensic photographer because they show how the past market trends have influenced the adoption of new photographic technology. Understanding this recurring pattern may help a forensic photographer to better understand how the photographic market is likely to affect what technology will be available within the next 2–5 years, especially when planning for future photographic capital equipment budgets.

Before the announcement of the daguerreotype, in 1835 Fox Talbot is reported to have produced a photographic negative (Hedgecoe, 1980, p. 22). This was followed in 1839 by Sir John Frederick William Herschel's discovery of hyposulphite of soda for fixing photographic images. Therefore, he was credited with developing hypo for fixing photographic images. Further, Herschel was also credited with coining the term "photography" (Davis, 1995, pp. 6–7; Hedgecoe, 1980, p. 20; further, according to Hedgecoe, it was Jean Hellot, who earlier used a photographic process to make secret writings visible by exposure to light, who coined the word "photography," which means "writing with light."). Also in 1839, William Henry Fox Talbot invented the **Calotype** which was a silver chloride–coated light-sensitive paper that was fixed with strong salt solution (Davis, 1995, pp. 5–6; Hedgecoe, 1980, p. 22). The calotype also appears to have been a commercially successful photographic process. The calotype was later patented by Talbot in 1841 (Hedgecoe, 1980, pp. 22–23). In my research into the history of forensic photography, I noted several conflicting dates related to several photographic inventions. Some of these conflicts may be due to any one of the following: mistake by other authors, using the date the research started, using the date the research first produced successful results, using the date the invention was announced, or using the date the invention was patented.

Both Talbot (calotype) and Daguerre (daguerreotype) later used Herschel's hypo to fix their photographic images (Davis, 1995, pp. 5–7).

From 1839 to 1841, there were three significant uses of daguerreotypes. In 1839, Noel Lerebors's scenic Daguerreotypes were copied by engravers for publication (Davis, 1995, p. 9). This use was significant because the printing/newspaper industry later became a major market for photographic equipment, supplies, and processors. In 1840, the first portrait studio in New York City was opened by Wolcott and Johnson (Newhall, 1964, p. 21). This use is significant because this was the first professional use of photographs in a market that is controlled by what the customer was willing to purchase. In 1841, the Paris police department may have been the first agency to use daguerreotype prisoner mug shots (Miller, 1998, p. 1; Scott, 1969, vol. 1, p. 2). Unfortunately none of these early photographs survived (New Zealand Police Museum, https://sites.google.com/site/newzealandpolicemuseum/home/online-exhibitions/mug-shots/inventionofmugshots.html). However, photographs taken of Belgium prison inmates in 1843 have survived (Answers.com, http://www.answers.com/topic/police-and-forensic-photography). Prisoner photographs were also reported to have been taken as early as 1844 in the United Kingdom (Wikipedia, http://en.wikipedia.org/wiki/Mug_shot).

In 1843 Josef Puchberger patented a **Panoramic Camera** in Austria with a curved daguerreotype plate and a rotating lens. Before this invention, panoramic photographs consisted of a series of photographs that were mounted side by side (Woeste, http://www.graphics.com/article-old/history-panorramic-image-creation; University of Washington, https://content.lib.washington.edu/panormweb/history.html). This process was also called butt splicing and was used up until about 2010 when film was almost totally replaced by digital cameras and digital imaging splicing software. The oldest known example of this type of panorama is a side by side mounted series of eight daguerreotypes taken in 1848 by W.S. Porter (Luhmann, http://www.isprs.org/proceedings/xxxiv/5-W16/papers/PanoWS_Dresden2004_Luhmann_a.pdf).

In 1844, Talbot developed an improved **Calotype** paper negative. This was a paper-negative process using gallic acid and silver nitrate solution with a hypo fixer. This is the process that eventually evolved into the photographic negative printing process that is in use today (Davis, 1995, p. 7). In the same year, Talbot's book *Pencil of Nature* was the first to use photographic illustrations with calotype prints (Davis, 1995, p. 9; Frizot, 1998, p. 62).

Many think of photogrammetry as a relatively recent merger of photography and mathematical analysis. However, in 1849 the "Father of Photogrammetry," Aimé Laussedat compiled topographic maps from terrestrial photographs (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 5). This is just before the first of four of Konecny's photogrammetry cycles which covered 1850 to 1900. This first cycle was called the "development of plane table photogrammetry" (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 3). Within this cycle in 1881, Aimé Laussedat created the foundation of the science of photogrammetry (University of Vienna website, Introduction to Photogrammetry). In 1853 in Germany, R. Sturms and Guido Hauck established the relationship between projective geometry and photogrammetry (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 2). This may be the basic foundation for what is now called **Reverse Projection Photogrammetry** used to determine the approximate height of persons recorded in CCTV surveillance videos. This was followed in 1855 by the invention of instruments for photogrammetry by J. Porro (Buchanan, http://elib.uni-stuttgart.de/opus/volltexte/2010/5142/pdf/bu14.pdf, p. 83).

Going back to photography, in 1851, there were several significant developments. Frederick Scott Archer developed the collodion or **Wet-Plate Process**. This consisted of an emulsion of iodized collodion immersed in a bath of silver nitrate coated on a glass plate. This emulsion had to be exposed while still wet, which led to the nickname of "wet-plate process." The emulsion was developed in either pyrogallic acid or a solution of ferrous sulfate (Davis, 1995, p. 8; Spira et al., 2001, p. 43). Finally, there was the first documented scientific examination of a photographic fake. This involved the claim by Reverend Levi Hill that he had developed a method to take color daguerreotype photographs (Davis, 1995, p. 18). However, two authors listed this color photography method as genuine (Newhall, 1964, pp. 269 and 272; Spira et al., 2001, p. 31). The issue was resolved in 2010 by Michelle Delaney who was the curator of the National Museum of American History's Photographic History Collection. A team consisting of Michelle Delaney, Corinne Dune, and experts from both the Getty Conservation Institute and the George Eastman House examined the Smithsonian's collection of 62 of Hill's daguerreotypes, also called **Hillotypes**. The researchers found that many of the hillotypes did have a limited range of colors. However, some of the hillotypes had been hand colored (Fiegl, http://www.smithsonianmag.com/arts-culture/a-160-year-old-photographic-mystery-8994798/?n0-ist).

Storage of these materials was relatively simple. They were stored in envelopes or boxes and in drawers or cabinets. Later it was discovered that some envelopes contained acids that could cause the deterioration of images in long-term storage. As a result, photographers and archivists began using acid-free/archival storage envelopes and storage boxes.

Another milestone was accomplished by Sir George G. Stokes when in 1852 he discovered **UV Fluorescence** and formulated **Stokes' Law** (Scott, 1969, vol. 2, p. 63), which is the fundamental theoretical basis of all fluorescent photography currently used in law enforcement. This theory is very simple. The wavelength of the fluorescence is always longer than the wavelength of the light that excited the fluorescence. The fluorescence will not be as bright as the exciting light source. What this means, in practice, is that if the film or camera sensor is sensitive to both the color of the **Exciter Light Source** (such as an argon-ion laser with an output at 514 nm) and the color of the fluorescent light (such as the fluorescent color of R6G dye-stained latent print evidence), you will need a **Barrier Filter** to block the exciter light source so that the film or sensor can record the fluorescence.

The first recorded use of photographs of wanted criminals being circulated to the public started in 1854 in Switzerland (New Zealand Police Museum, https://sites.google.com/site/newzealandplicemuseum/home/online-exhibitions/mug-shots/inventionofmugshots.html). The rouges gallery opened by the New York City Police Department in 1857 or 1958 appeared to be more of a public relations effort which was criticized for humiliating criminals (Marquette University, http//law.marquette.edu/facultyblog/2013/10/16/a-history-of-the-mug-shot/).

From 1854 to 1855, three new photographic processes became available that produced lower-quality photographs but were cheaper than the daguerreotype process. Starting in 1854, J. A. Cutting invented the **Ambrotype**. The ambrotype is a collodion on a glass base. It was cheaper and easier to process compared to the daguerreotype process (Davis, 1995, p. 10). In the same year, André-Adolphe-Eugene Disdéri invented and patented the **Carte-de-Visite** process, which was an albumin emulsion coated on paper. Again, carte-de-visite was cheaper and easier to process compared to the daguerreotype process (Davis, 1995, p. 10; Spira et al., 2001, pp. 55–62). In the following year, Hamilton Smith invented the **Tintype**, which is also called a ferrotype. It is a collodion emulsion coated on metal. Again, the tintype was cheaper and easier to process compared to the daguerreotype process. Because of the cost, even high-end portrait studios had to convert from the higher-quality daguerreotype because customers, in general, were more interested in how much they had to pay for the portraits (Davis, 1995, p. 10). So what does this mean for today's forensic photographer? Basically, the professional portrait photographers determined which cameras were being purchased, and thus their purchases determined the camera side of the market simply because there did not appear to be any significant amount of photography done by amateur photographers up to this point. However, in terms of the recording medium, it was what amateur consumers were willing to purchase that appears to have controlled which media is used and which media becomes obsolete. Although this is very simplistic compared to today's market, studio owners had the same problem when planning for future purchases of cameras and recording media that forensic photographers have today. The successful studios probably looked at, which cameras their fellow professionals purchased and then decided which of these cameras best suited their needs. The successful studios probably looked at, how many amateur consumers were willing to pay for portraits and then decided on one of the photographic processes (equivalent of film today) that would allow them to make a profit at this price.

Now going back to the history, the next major event was accomplished in 1858 by French photographer and balloonist Gaspar Felix Tournachon, nicknamed "Nadar," who took the first known aerial photograph of the French village of Petit-Becetre. Because he was using the wet plate process, he had to carry a complete darkroom in the basket of the tethered hot-air balloon that he used (Jeffrey, 1998, p. 220). Emperor Napoleon recognized the military value of aerial photography, and in 1859 ordered Nadar to take aerial reconnaissance photographs. Also, in 1858 the first panoramic cameras designed for use in photogrammetry were built independently by both Porro and Chevallier. Unfortunately, neither of these cameras was accurate enough to be used for photogrammetry (Luhmann, http://www.isprs.org/proceedings/xxxiv/5-W16/papers/PanoWS_Dresden2004_Luhmann_a.pdf, p. 6).

Although it could be argued that forensic image analysis began in 1851 with the scientific examination of a faked-color daguerreotype, it was not until 1859 when the United States Supreme Court ruled on the admissibility of photographs used as evidence in Luco v. US, 64 US (23 How.) 515, 162 L. Ed. 545 (1859). In this case, the Court ruled that photographs of a document were properly admitted in place of the original document, for the purpose of proving that a land grant title document was a forgery (Miller, 1998, p. 1; Scott, 1969, vol. 1, p. 2–3). Soon after this case in the 1860s the use of the American wanted posters became common in the Western United States (New Zealand Police Museum, https://sites.google.com/site/newzealandpolicemuseum/home/online-exhibitions/mug-shots/inventionofmugshots.html).

Stereophotography was very popular for a time, and by 1860 stereo viewers with stereoprints and stereo transparencies were commonly found in upscale homes (Davis, 1995, pp. 10–12). You can still find these viewers in flea markets, but from the limited number of vendors who serve this small amateur niche market, it was never used to any significant extent by law enforcement agencies in the United States. However, a combination of stereophotography principles, combined with a VR camera system (such as the pan-and-scan camera system) and photogrammetry software to make a VR image of the crime scene with interactive measurement capabilities, is being using by law enforcement agencies in the United States.

From a technology standpoint, there was a very interesting development in color photography in 1861. Maxwell and Sutton were able to successfully make color separation negatives, which, when projected through the corresponding red, green, or violet filter to which they were photographed through, resulted in a color image of the object photographed. What makes this interesting is that the film at that time was **Orthochromatic** (no sensitivity to red light) so that, in theory, it should not have worked. However, in 1961, Ralph Evans proved that it could have



FIGURE 1.3
This Civil War photograph by Alexander Gardner was taken in 1863 and first reproduced as a picture of "Death Confederate Soldiers" and later reproduced and captioned as a picture of "Death Union Soldiers."
Photograph courtesy of Library of Congress, Prints and Photographs Division. Reproduction Number LC-B8184-7964-A.



FIGURE 1.4
This Civil War photograph by Alexander Gardner was taken in 1863. The "Scene Reported To Have Been Created By Posting The Body" to create the scene.
Photograph courtesy of Library of Congress, Prints and Photographs Division. Reproduction Number LC-B8171-7942.

worked because of the fluorescent properties of the red dye in the object photographed (Davis, 1995, p. 18). This is the first recorded use of RGB color separation negatives to reproduce a color image. An understanding of color separation negatives is still useful today to better understand how to process digital RGB images in software such as Adobe Photoshop.

Also in 1861, Mathew Brady began coverage of the American Civil War using the profits from his portrait studios to finance his team of photographers (Davis, 1995, pp. 10–12). Although Brady was probably the most well-known, there were several other photographers who photographed the American Civil War. The Civil War photographs in Figs. 1.3 and 1.4 that were taken by Alexander Gardner illustrate a misrepresentation of what is depicted. This type of misrepresentation could have been the start of some form of public mistrust in what is depicted in a photograph.

An important development in 1865 for photogrammetry was the Paulo Ignazio Pietro Porro's invention of a photogoniometer which was designed to remove lens distortion (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 6). In this same year, Porro also invented a phototheodolite which is a combination of a camera and theodolites. If I understand this correctly the phototheodolite could both take photographs and also be used to measure angles for the viewpoint of each photograph for photogrammetry purposes (Luhmann, http://www.isprs.org/proceedings/xxxiv/5-W16/papers/PanoWS_Dresden2004_Luhmann_a.pdf).

Crime scene photography dates back to 1867. The overall law enforcement marketing strategy in 1867 for a crime scene camera parallels many of the sales pitches used by persons selling digital camera systems today (see Fig. 1.5). We may laugh about an advertisement's statement that the camera will replace sketches, but this theme is reminiscent of the sales pitch used in the mid-1980s to sell the U S military on a total conversion to digital photography.

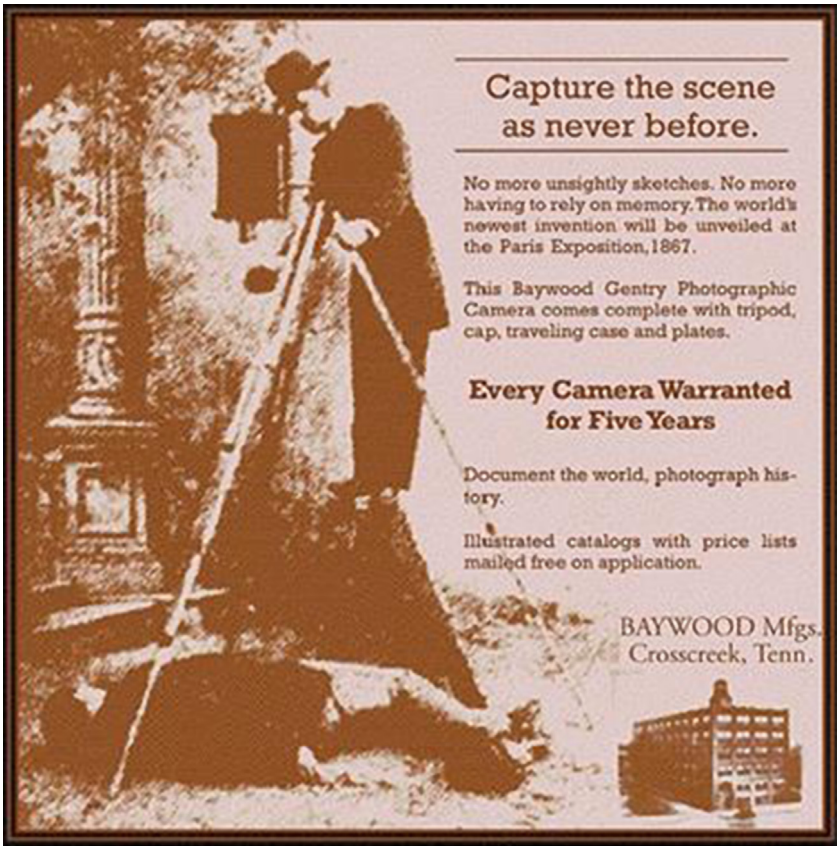


FIGURE 1.5
First known advertisement for a crime scene camera in the United States.
Photograph courtesy of Lighting Powder Company.

The 1860s and 1870s ushered in the era of the fake **Ghost Photographs** used to commit fraud. The basic fraud was very simple. Criminals would scan the newspapers for the names and addresses of the wealthy relatives of recently deceased persons. With this information, the criminals would approach their victims and offer to hold a séance for a fee to enable the victims to contact the spirits of the recently deceased relatives. For an additional fee, the criminals would also provide a photograph of the victims with these spirits. These **Spirit Photographs** were faked by a double exposure either in the camera or in the darkroom. Fig. 1.6 shows a newspaper report of a criminal case involving ghost photographs and expert photographic testimony in the United States (Becker, http://www.photographymuseum.com/mumler.html). By the turn of the century, books were being published on trick photography (see Fig. 1.7).

The year 1870 was a milestone for mug shots. The first-known mug shot collections were established in London (Answers.com, http://www.answers.com/topic/police-and-forensic-photography). In the United States, it was not a government police agency, but the Pinkerton National Detective Agency that first established a large mug shot collection (Wikipedia, http://en.wikipedia.org/wiki/Mug_shot). In Europe several police agencies also established mug shot collections to include Paris in 1874 and Berlin in 1875. Even though there is some disagreement over whether it happened in the 1870s (Answers.com, http://www.answers.com/topic/police-and-forensic-photography) or in 1888 (Wikipedia, http://en.wikipedia.org/wiki/Mug_shot), the Paris Police Department mug shot collection was organized by Alphonse Bertillon based on his anthropometric measurement identification system measurements of each individual who was photographed (Answers.com, http://www.answers.com/topic/police-and-forensic-photography).

There are three things that do not appear to be in dispute. Alphonse Bertillon (see Fig. 1.7) developed the specifications in 1888 for what is considered the modern mug shot consisting of a full facial photograph and a profile photograph of the person's head (Wikipedia, http://en.wikipedia.org/wiki/Mug_shot). These specifications were published in 1890 in Bertillon's "La Photographie Judiciaire" book (Answers.com, http://www.answers.com/topic/police-and-forensic-photography). Because of the widespread adoption of the specifications in this book, Bertillon is considered to be the inventor of the modern police mug shot. Bertillon is also reported to be the first person to have systematically documented crime scenes (Wikipedia, http://en.wikipedia.org/wiki/History_of_forensic_photography).



FIGURE 1.6
In this New York City case, there was expert testimony as to how the ghost photographs likely were faked.



FIGURE 1.7
Mug shot style photograph of Alphonse Bertillon.

The next major advance in the development of photographic film emulsion was the discovery in 1873 by Dr. Hermann Wilhelm Vogel of **Dye-Sensitizing** technology that extended the color sensitivity of black-and-white films into the red region of the visible light spectrum. This was the key discovery that led to the development of modern black-and-white **Panchromatic Film** (Davis, 1995, pp. 18–19).

The 1870s also saw continued recognition of the admissibility of photographic evidence by the courts in the United States. In 1874, the Pennsylvania State Supreme Court in the case of Udderzork v. Commonwealth, 76 Pa. 340 (1874) affirmed judicial notice of the use of photographs as an established means of reproducing a correct likeness of a person (Scott, 1969, vol. 1, p. 4). In 1875, the Massachusetts State Supreme Court in the case of Blair v. Inhabitants of Pelham, 118 Mass. 420 (1875) affirmed the use of traffic accident photographs to show the road conditions that were a factor in the traffic accident (Miller, 1998, p. 1). Later in 1879, the Iowa State Supreme Court affirmed the admissibility of tintype photographs of injuries in the case of Redden v. Gates, 2 N.W. 1079, 50 Iowa 210 (1879) (Scott, 1969, vol. 1, p. 5; Miller, 1998, p. 2).

The science of photogrammetry was also evolving. According to the University of Vienna website, archaeologists in 1885 used photogrammetry to record and document the ancient ruins of Persepolis. Plus, in 1889, C. Koppe published the first German Manual of Photogrammetry (University of Vienna website, http://www.univie.ac.at/Luftbildarchiv/wgv/intro.htm). Many of the early applications of photogrammetry were related to mapping geological features. For example, aerial photogrammetry from a balloon was used by S. Finsterwalder to study glaciers (Buchanan, http://elib.uni-stuttgart.de/opus/volltexte/2010/5142/pdf/bu14.pdf, p. 83). In 1893 a U S patent was granted to Cornele B. Adams for a method of aerial photogrammetry based on the analysis of two aerial photographs taken from a balloon, and the term "photogrammetry" was first used by Dr. Albrecht Meydenbauer (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 8).

The historical question of who first invented flexible transparent film began with the Reverend Hannibal Goodwin applying for a patent in 1887 that was not granted until 1898, after the granting of the Eastman patent application that was filed in 1890. The final question was answered by the courts in 1914 when Ansco, the company that acquired Goodwin's legal rights, won a civil lawsuit against Eastman Kodak in the amount of $5 million (Davis, 1995, p. 17). Another invention in the late 1800s was the Al Vista panoramic camera in 1899 (Luhmann, http://www.isprs.org/proceedings/xxxiv/5-W16/papers/PanoWS_Dresden2004_Luhmann_a.pdf).

Banks first began to use cameras to photograph persons attempting to break into them in 1887. In 1893, bank photographs were used to identify a bank robbery suspect in New York City (Scott, 1969, vol. 1, pp. 5–6). Just as film-based photography has evolved into digital photography, this can be considered the beginning of what is evolving into the imaging subspecialty of forensic video analysis.

In this same time period, aerial photography was in its early beginnings. In 1887 James Fairman patented an "apparatus for aerial photography in the United States" (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 7), and panoramic cameras were also reported to have been produced (Wells et al., 2007). In 1897, Alfred Nobel took the first successful aerial photograph with a rocket-mounted camera (Scott, 1969, vol. 1, p. 7). In 1898 the US Army is reported to have used kites to take aerial reconnaissance photographers during the Spanish-American War (Shaw, 2013). By 1903, the Bavarian Pigeon Corps was using their pigeons to take aerial photographs with a camera designed by Julius Neubranner (Professional Ariel Photographer's Association International Website, http://www.papainternational.org/history.html).

The turn of the century saw many important developments in photographic technology and photogrammetry. Konecny grouped the evolution of the science of photogrammetry into "four development cycles." The second cycle was the "Development of Analog Photogrammetry" from 1900 to 1960 (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 3). The person commonly credited as being the "Father of Stereophotogrammetry," Dr. Carl Pulfrich, invented the first stereocomparator (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 12). In 1904, the Lumiere brothers patented the autochrome color photography plates that were put into production in 1907 (Frizot, 1998, p. 414). The Cirkut panoramic camera was patented in 1904 by William J. Johnson (Spira et al., 2001, p. 115 and Wikipedia, https://en.wikipedia.org/wiki/Cirkut). This camera was unique because both the camera and film rotated (University of Washington, https://content.lib.washington.edu/panormweb/history.html). The International Society for Photogrammetry was formed in 1909 (PG3, p. 34), and they held their first congress in Vienna, Austria in 1910 (Tewinkel, n.d., p. 1, http://www.ngs.noaa.gov/web/about_ngs/history/history_of_photogrammetric_mapping.pdf.). However, it was not until 1934 that the American Society for Photogrammetry was formed (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 34). By 1910, Kodak dominated the amateur market, and most of today's photographic techniques had already been developed (Davis, 1995, p. 17). In 1912, Siegrist and Fischer were able to produce color images by chemically forming dyes in the emulsion layer during development (Davis, 1995, p. 19).

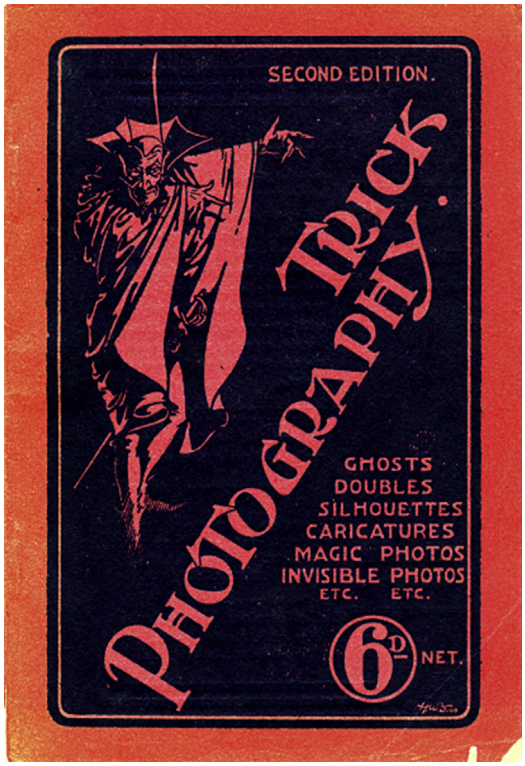


FIGURE 1.8
This is the cover of a 1907 book describing how to take and/or make trick photographs.



FIGURE 1.9
Composite Photograph image of the Houdon bust and the corpse of John Paul Jones.
Photo courtesy Naval Historical Center, Washington, D.C.

When persons discuss how easy it is to alter digital images, they are usually not aware of early books on simple film-based trick photography which describe how easy it was to make trick photographs. Two of the trick photography books published in 1907 were *Trick Photography*, 2nd ed. by Rickard Penloke (see Fig. 1.8) and *How To Take And Fake Photographs*, 5th ed. By Clivem Holland which was reprinted in 2014.

These early photographic technologies were also being applied in forensic applications (see Fig. 1.9). The Massachusetts State Supreme Court upheld the admissibility of a firearms identification photograph in Commonwealth v. Best, 62 N.E. 748, 180 Mass. 492 (1902) (Miller, 1998, p. 2). By 1907, all intoxicated persons in Denver, Colorado, were being photographed by the police department (Miller, 1998, p. 2), and the state of Massachusetts approved the use of photographic speed recorders to detect speeders (Miller, 1998, p. 2). This remains a controversial application even today, when used at traffic lights to catch vehicles running red lights in addition to speeding.



FIGURE 1.10
This is a reconstruction of a 1924 Hirose Photo Studio. At this time north lighting was considered to be the ideal lighting for portrait photography. Because of this the studio was designed with a north facing skylight window to provide north lighting. The interior rooms were designed based on workflow and customer considerations.

In 1915, several professionals formed the International Association for Identification, which has evolved into the oldest and largest forensic science organization in the world; it represents several forensic disciplines including forensic imaging. This was followed in 1948 by the formation of the American Academy of Forensic Sciences, which has members from over 59 countries; the academy has a digital and multimedia evidence discipline that represents forensic photographers (AAFS Information Letter included in CFSO lobbying packet, 2001).

The Ohio Appellant Court was in the forefront of defining the standard for the admissibility of imaging evidence when it ruled in the case of Duncan v. Kiger, 6 Ohio App. 57 (1916), that a motion picture was not admissible because it did not show the details clearly enough to be useful (Scott, 1969, vol. 1, p. 8). Because the motion picture was not an accurate **Representation**, this is consistent with the current requirements that a photograph must be relevant, material, a fair and accurate representation, and not overly prejudicial to be admissible in most jurisdictions in the United States.

With the recent rise of law enforcement uses of aerial photography **Drones** and aerial photography, in general, there are some early devices that needed to be added. The 1917 radio-controlled "aerial torpedo" or "flying bomb" developed by Elmer Sperry (Shaw, 2013) was historically important even though there is no record of it being used for photography, because it was one of the first radio aircraft for use other than as a hobby. Many old-time film users will remember the 1920 Fairchild K-3 camera and it predecessors. These predecessors were used in both the Explorer II balloon flights and the Apollo missions (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 22).

Looking at past examples can be useful when building or remodeling a law enforcement imaging unit. Take, for example, this reconstruction of a 1924 Hirose Photo Studio (see Figs. 1.10 and 1.11) located in Hokkaido Pioneer Village near Sapporo, Japan. It was designed to utilize north lighting for portrait photography and have an efficient layout based on a combination of workflow, sales, and customer convenience. The important point is that instead of putting a law enforcement imaging unit in whatever space is left over, you need to design the floor plan based on what is to be photographed, the types of photographic lighting that need to be used, the transfer and secure storage of evidence, image processing workflow, storage of equipment and supplies, storage of imaging files, temperature control, power requirements, and network connections.

This is a bone for the trivia buffs. The first version of the Leica 1 in 1925 (possibly a prototype) had a Z shutter speed setting. Z stands for the German word "Zeit" which translates to the English word "time." This was latter called the T- or time-exposure setting (Wikipedia, http://www.wikipedia.org/wiki/Leica_Camera). You will probably only find a T setting on older film cameras. In the T setting, you press the shutter release cable once to open the shutter and press shutter release a second time to close it. Although on at least one camera, you had to rotate the shutter speed dial from the T setting to close the shutter. What is more than just trivia is the 1930 Leica I Schraubgewinde, which introduced the Leica thread mount interchangeable lens system (Wikipedia, http://www.wikipedia.org/wiki/Leica_Camera).



FIGURE 1.11
This is the photo studio with the north facing skylight window on the left. This provided lighting with less need for artificial lights. The window curtains, combined with reflectors provided most of the lighting.

Moving on, by 1930 the newly invented flashbulb was in widespread use (Miller, 1998, p. 2). This portable light source made possible the taking of many evidence photographs that might otherwise have been unobtainable. To give you an idea of how powerful these flashbulbs were, a #50 flashbulb that was about the size of a 500-W photoflood bulb could be used to take a photograph of an average-sized charred living room on 8 × 10 Tri-X at F22 at 1/60 s on M sync. Flashbulbs, however, did have three drawbacks. First, immediately after being fired, they were very hot. Second, as claimed by some US Army, signal corps photographers, they can be set off by high-power microwave transmitters. Third, they will explode if the protective coating is damaged or removed.

As imaging technology was advancing, courts in the United States were ruling on the use of this emerging technology and were developing the current standards of admissibility. An Ohio appellant court in 1928 (Beach v. Chollett, 31 Ohio App. 8 (1928)) ruled that photographs of X-rays were not admissible in place of the X-rays because the photographs did not show some significant details that were visible in the original X-rays (Scott, 1969, vol. 2, p. 41). This is a very simple standard that is independent of technology. To be admissible, an image must be a photographic reproduction of the original object that is accurate enough to assist the jury without misleading the jury about what the original object looked like. By 1930, the courts had accepted sound motion picture recordings of confessions (Commonwealth v. Rollen, 100 P. Super. 125 (1930), Scott, 1969, vol. 1, p. 9). In 1931, the Illinois State Supreme Court (People v. Greenspawn, 179 N.E. 98, 346 ILL. 484 (1931)) affirmed the use of X-rays by a dentist to identify a person (Scott, 1969, vol. 2, p. 51). The New Hampshire State Supreme Court in State v. Thorp, 171 A. 633, 86 N.H. 501 (1934) upheld the admissibility of an ultraviolet photograph of footprints in blood (Scott, 1969, vol. 1, p. 9). In addition to looking at the final photograph, the courts in several states, to include Massachusetts (Snyder v. Massachusetts, 54S.Ct. 330, 291 US 97, 78 L.Ed. 674 (1934)), were also looking at the photographer. "In careless, unskilled, or uninterested hands, photography sometimes produces misleading and confusing results" (Scott, 1969, vol. 2, pp. 339–341). In addition to being useful for forensic photographers to justify why they need professional training, these cases further defined what is now referred to as a **Fair and Accurate Photographic** representation. Therefore, if a photograph is determined to be misleading or confusing, it is not a fair and accurate photographic representation of the original object. The case of US v. Morton, 107 F.2 d 834 (C.C.A.2, 1938) in 1938 was an early case in which the admissibility of the microfilm of a document was admitted in place of the document (Scott, 1969, vol. 1, p. 10); the admissibility of a color photograph was upheld in the case of Green v. City and the County of Denver, 142 P.2 d 277, 111 Colo. 390 (1943) (Scott, 1969, vol. 1, p. 10; Miller, 1998, p. 3); and the admissibility of an **IR Photograph** of erased writing was upheld in the case of Kauffman v. Meyberg, 140 P.2 d 210, 59 Cal. App. 2d 730 (1943) (Scott, 1969, vol. 1, p. 10).

Imaging technology as well was not standing still. In the 1930s, dye-destruction color film technology was developed, and this technology was later used in Ilfochrome (Davis, 1995, p. 19). The Leica Model II camera was introduced in 1932, and the Contax Model I camera was introduced in 1933 (Canon, http://www.canon.com/camera-museum/history/canon_story/1933_1936/1933_1936.html). In either 1935 or 1936 the Hansa Canon 35 mm rangefinder camera with a focal plane shutter was sold in Japan. The camera was a joint project of the Precision Optical Instruments Laboratory (later became Canon Camera Company) and Nippon Kogaku (an optical manufacturer from which the Nikon Camera Company later evolved). This copy of a Leica camera used a rangefinder and lens made by Nippon Kogaku (Canon, http://www.canon.com/camera-museum/history/canon_story/1933_1936/1933_1936.html). In September of 2014, a Hansa Canon with a Nikkor lens in good working condition was listed on e-bay for $16,666.00. Later Canon rangefinder cameras used lenses designed and manufactured by Precision Optical Instruments Laboratory. One of these later Canon rangefinder camera lenses that always stood out for me ever since I saw one in a used camera store in Japan was the F0.95 50 mm Canon lens that was used by news and sports photographers. The Super-Six-20 camera introduced by Kodak in 1938 featured an automatic exposure capability (Miller, 1998, p. 3). According to the photography network website, the first stroboscopic flash system was developed in 1939. Kodak introduced Kodacolor color negative film in 1941 (Davis, 1995, p. 19; Miller, 1998, p. 3), Ektachrome color slide film in 1942, and Ektacolor color negative film in 1947 (Davis, 1995, p. 19). Rochester was home to both Kodak and Bausch and Lomb. Bausch and Lomb is probably the most well-known among photographers for camera lenses. However, in 1940 they began manufacturing stereoplotting systems for mapping (Tewinkel, http://www.ngs.noaa.gov/web/about_ngs/history/history_of_photogrammetric_mapping.pdf, p. 2). A competitor of Kodak, Edwin Land, invented the Polaroid Land Camera in 1947 (Scott, 1969, vol. 1, p. 11). This was followed in 1948 by the invention of Polaroid black-and-white print film (Scott, 1969, vol. 2, p. 227). The year 1948 also marked the sale of the Nikon 1 rangefinder camera (Digital Picture Zone, http://www.digitalpicturezone.com/featured/secrets-behind-the-growth-and-popularity-of-canon-and-nikon.html). Part of the reason for tracking the history of Canon and Nikon cameras is because these are two of the most commonly used brands of DSLR cameras used for crime scene photography in the United States.

One of the early crime laboratories to establish separate units for the forensic examination of imaging evidence was the FBI laboratory when its photographic operations unit was split in 1942 into a processing unit, and a special photographic unit that has evolved into the current forensic audio, video, and image analysis unit. At the state level, each crime laboratory has evolved in its own unique way. In some states, the crime laboratory is part of the state police; at least one state has the crime laboratory director as a cabinet-level position in the governor's office, while several states, like Wisconsin, have their crime laboratories under the state department of justice. The Wisconsin state crime laboratory was created first in Madison by state statute in 1947, with photography being listed as a separate forensic discipline. This highlights two points that are important for forensic photographers. First, photography being listed in the state statute as one of the forensic disciplines helped in getting forensic photographers classified as forensic scientists and on the same pay scale as other forensic scientists. Second, forensic photographers have to be aware of how human resources departments generally use both a job description and a market survey to determine a salary range for a given job classification.

Jails were also impacted by developments in imaging technology. In the 1940s, color photography was the first major change in mug shot photographs. However, this change did not solve a problem in some jails of prisoners swapping identities between the time they were booked and the time they were assigned a jail cell. In the early 1980s, before digital booking photographs, one sheriff's department south of Atlanta, Georgia, solved this problem by the use of Polaroid print film so that the booking photograph was available instantly to prevent long-term prisoners from swapping identities with prisoners who were only going to be held overnight. This problem has been almost completely eliminated by the use of digital photographs that are imported immediately into electronic booking records that are then available at any computer terminal in the jail.

The application of the best evidence rule to imaging evidence still sparks emotional debates similar to the arguments between Nikon and Canon owners over who has the best camera, or PC and Apple computer users over who has the best computer. What may have started this debate in the United States is the 1884 case of Barrow-Giles Lithographic Co. v. Sarony, 4 S.Ct. 279, 111 US 53, 28 L.Ed. 349 (1884), in which the court ruled that photographs are documents under Article 1, Section 8 of the United States Constitution (Scott, 1969, vol. 2, p. 304). However, the Tennessee State Supreme Court held in Brown v. State, 210 S.W.2 d 670, 186 Tenn. 378 (1948) stated that the best evidence rule does not ordinarily apply to photographic evidence (Scott, 1969, vol. 2, p. 306).

By this time, a general foundation for the admissibility of photographs as demonstrative evidence had evolved for an instance in which there was a witness with first-hand knowledge of what was depicted in the photograph. This general foundation is very simple and has been applied to digital photographs and digital video recordings. The photographs must be relevant and material to the case. Unless there is a stipulation by the opposing party, a witness with first-hand knowledge of what is

depicted in the photograph must testify that the photograph is a fair and accurate photographic representation of what the witness saw. The probative value must not be outweighed by the prejudicial effect (gruesomeness or inflammatory effect) (Miller, 1998, p. 6). In 1951, an additional requirement was added: A photograph, like other documents, must be submitted to the opposing party before being admitted as evidence (Spence v. Rasmussen, 226 P2d 819, 190 Or. 662 (1951)) (Scott, 1969, vol. 2, p. 304). An interesting development is that among those professionals who do not know photographic history, there has evolved a mistaken belief that it is difficult or impossible to alter a film-based photograph and easy to alter a digital photograph. This has resulted in some agencies adding a **Chain of Custody** requirement when switching to digital cameras regardless of court decisions and many vendors marketing products that they claim will ensure the admissibility of the photographs taken by or at the direction of a law enforcement agency. Do not confuse this with the silent witness rule. This does require a chain of custody for photographs that have been seized as physical evidence.

The 1950s and 1960s also saw several important developments in imaging technology. The Canon IVSb camera introduced electronic flash synchronization (Canon Digital Camera Blogspot, http://canondigicamera.blogspot.com/2011/03canon-digital-camera-history.html). On older cameras with sync settings for electronic flash, this would be called X sync. The X sync setting would trip the electronic flash just as the shutter starts to open. While the M sync setting was designed to trip a flashbulb slightly before the shutter opened so that the flashbulb would reach peak brightness while the shutter was open. The 1951 United States Air Force (USAF) resolution test chart was designed based on the MIL-STD-150A standard. Although this standard has been rescinded, this test chart is still in use today to test the resolving power of cameras and scanners (Wikipedia, https://en.wikipedia.org/wiki/1951_USAF_resolution_test_chart). The videotape recorder was introduced in 1957 (Settel and Laas, 1969, p. 105). Prior to this invention, video was recorded on motion picture film and played back through a **Telecine Machine** to convert the motion picture film image and sound into an electronic video image with sound. Variations of the old telecine machine are still in use today to copy old motion picture films to videotape. The year 1959 ushered in three major advances. Xerox made their first photocopier (Digital Photography Tips Network, http://www.digital-photography-tips.net/history-of-digital-photography-early-days.html) Modern-flatbed scanners evolved from this technology. If the rumors are true, the photocopier technology was first rejected by IBM as not being likely to have any significant business applications. The other two advances were the introduction of Canon's and Nikon's first 35 mm single lens reflex cameras (SLR). These were the Canon's Canonflex and the Nikon's Nikon F (Canon, http://www.canon.com/camera-museum/history/canon_story/1955_1969/1955_1969.html). The year 1960 marked the start of the third of four of Konecny's photogrammetry development cycles, which was called analytical photogrammetry (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, p. 3). The 3-D scanners developed in the early 1960s were not applied to documenting crime scenes. These early scanning devices used light cameras and projectors (Artescan Blog, http://artescan.net/blog/3-d-laser-scanner-history and SurvTech, http://floridalaserscanning.com/3d-laser-scanning/history-of-laser-scanning/). By 1962 the United States was using drones for photographic surveillance in foreign countries (Shaw, 2013). However, these were so expensive that most law enforcement agencies would likely have found a manned airplane or helicopter more cost-effective. In 1963, Polaroid Polacolor instant print film was announced (Miller, 1998, p. 4). By 1965, Super 8 mm movie equipment was introduced and became a hit with consumers until it was replaced with video camcorders (Scott, 1969, vol. 1, p. 11). In this same year, fully automatic electronic flash units became available for still photography (Miller, 1998, p. 4; Scott, 1969, vol. 2, p. 11). This decade seemed to have saved the best for last with the 1969 Bell labs invention of the charge-coupled device (CCD) (Brooke, http://www.bobbrooke.com/digitalstudio/digitalhistory.htm).

This new technology and the development of forensic imaging as a valid science were increasingly being accepted by the courts in the 1960s and 1970s. Videotapes began to be used as evidence in 1967 (Miller, 1998, p. 4). In 1970, the Ninth Circuit Court of Appeals affirmed the admissibility of facial identification testimony by a forensic photographer who demonstrated similarities of the nose, mouth, chin line, hair lines, ear contours, and the inner folds of the ears, US v. Cairns, 434 F2d 643 (9th Cir., 1970). Based on this information, it appears that the expert witness properly based the facial identification on both class and individual characteristics, which distinguishes it from the court's ruling in 1974. In 1974, the Ninth Circuit Court ruled it was harmless error to admit the expert facial identification testimony based only on class characteristics that could have been evaluated by the jury, while at the same time affirming the admissibility of expert testimony on clothing and weapons comparisons, US v. Brown, Docket Number 73–2279 (9th Cir., 1974). In 1975, the Second Circuit Court affirmed the admissibility of expert testimony by a forensic photographer related to facial comparison, and that the defendant and the person depicted in a bank film were about the same height, US v. Brown, 511 F2d 920 (2nd Cir., 1975). These cases appear to be consistent with the current comparative analysis standards of what has evolved into photograph ACE-V comparative analysis.

Another discipline using photographs for comparative analysis is forensic odontology. In 1978, a California Court of Appeals affirmed the admissibility of bite mark photographs used for comparison purposes by a forensic odontologist, People v. Slone, 76 Cal.App. 3d 611 (1978) (Scott, 1969, vol. 1, pocket part p. 109).

The beginning foundation that evolved into ACE-V in the latent print community may have begun in 1973 with the completion of the 3-year study conducted by the International Association for Identification Standardization Committee, which concluded that "no valid basis exists at this time for requiring that a predetermined minimum of friction ridge characteristics must be present" (Ashbaugh, 1999, pp. 1–2). ACE-V is an acronym for a scientific protocol for comparative analysis consisting of the following four overlapping steps: analysis, comparison, evaluation, and verification. This is significant for forensic photographers because this ACE-V methodology is also used by forensic photographers when conducting photographic comparisons.

In 1973, the American Society of Crime Laboratory Directors (ASCLD) was formed (ASCLD Website, http://www.ASCLD.ORG). ASCLD-LAB later evolved from ASCLD as a separate organization with the primary mission to accredit crime laboratories. Also, according to an unpublished IAI forensic photography subcommittee survey I conducted in the mid-1980s, there were already two state and two federal crime laboratories with photo/video examiner units that examined photographic and video evidence. Further, 35 additional state crime laboratories examined photographic and video evidence using forensic scientists in other disciplines, usually latent print examiners, questioned document examiners, or toolmark and firearm examiners. Further, in 2002 the digital and multimedia discipline was added; it included the subdisciplines of image analysis and video analysis for laboratory accreditation. As a result of this, in 2003 SWGIT, SWG-DE, and ASCLD-LAB worked in cooperation to define this new discipline and its four subspecialties. In 2003, SWGIT also began work on recommendations for simplified standard note-taking procedures for digital imaging and forensic video analysis. The practical impact is that as digital imaging replaces conventional photography, more detailed notes are required, and photographers must learn new digital skills in addition to all the previously needed conventional photographic skills. The LEVA was founded in 1989. In 1999, LEVA began forensic video analysis training and, in 2001, added a forensic video category to its annual technical awards (LEVA Website, http://www.LEVA.org). In 2002, the International Association for Identification formally recognized in IAI Resolution 2002–12 that "forensic video analysis has been recognized within the International Association for Identification as a valid subspecialty of forensic imaging" for over 20 years and was included within the forensic photography and electronic imaging subcommittee.

Technology and software continued to evolve in the 1970s and 1980s. In the mid-1970s, Matsushita developed the VHS videotape format (Miller, 1998, p. 4) that became a mainstay for many years in crime scene videography; it was used as the in-car camera system in police patrol cars, amateur camcorders, time-lapse CCTV, VCRs, commercial videotapes (movies) for sale and rental, and, to a limited extent, it was also used by some commercial TV stations. In 1976 a team led by C. S. McCamy at the Macbeth color checker. This color standard chart is still in use today and is more commonly known as the Gretag-Macbeth color checker. Over the years, there have been several evolutions in this chart. The Color Checker Digital SG became available in 2006. In 2009 the Color Checker Passport was introduced by X-Rite (Pascale, Danny. http://www.babelcolor.com/main_level/ColorChecker.htm) (see Fig. 1.12). Rags Gardner also developed a method to calibrate digital cameras in Adobe Photoshop's Adobe Camera Raw using the Gretag-Macbeth



FIGURE 1.12
In the background is a GretagMacbeth Color Checker © X-Rite. In the left foreground is a mini ColorChecker © X-Rite. In the right foreground is a Color Checker Passport © X-Rite.

color checker (Gardner, http://www.rags-int-inc.com/PhotoTechStuff/AcrCalibration). In 1977, Dalrymple, Duff, and Menzel published the results of their research into and practical application of laser dye-staining of superglue-fumed latent prints that are then photographed under a laser or **Alternate Light Source** (primary output at approximately 514 nm–blue green) with an appropriate barrier filter (usually orange) (Scott, 1969, vol. 1, pocket part pp. 59–61); see Figs. 1.13 and 1.14. In 1978 two Kodak engineers patented a digital camera that used a CCD sensor (Cameras Reviewed, http://cameras.reviewed.com/news/digital-camera-inventor-inducted-into-cea-hall-of-fame-15625). The 35 mm point-and-shoot camera became available in the 1980s (Miller, 1998, p. 4). In addition to the obvious amateur market, it was also used by law enforcement first responders, enabling them to take quick snapshots of a scene with minimal impact on their main duties at a traffic accident or crime scene. In this same time period, reasonably-priced

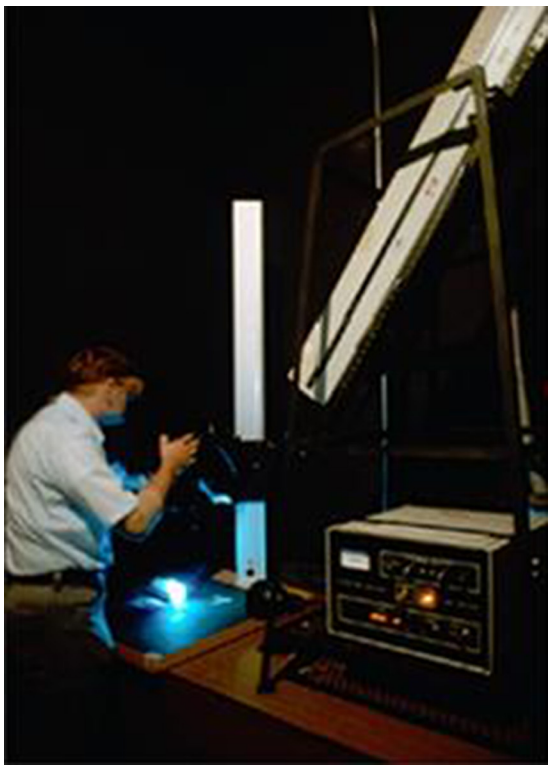


FIGURE 1.13
This is an early 5-W argon-ion laser. In the beginning, there were no metal-clad optical cables, so the laser was either pointed directly at a diffusion lens and then onto the laser dye-stained latent print evidence or routed by a series of mirrors. This technique resulted in a serious hazard. Because forensic photographers could not see the laser beam with safety goggles on, it was very common for them to move their arm or hand into the laser light path, resulting in serious burns.

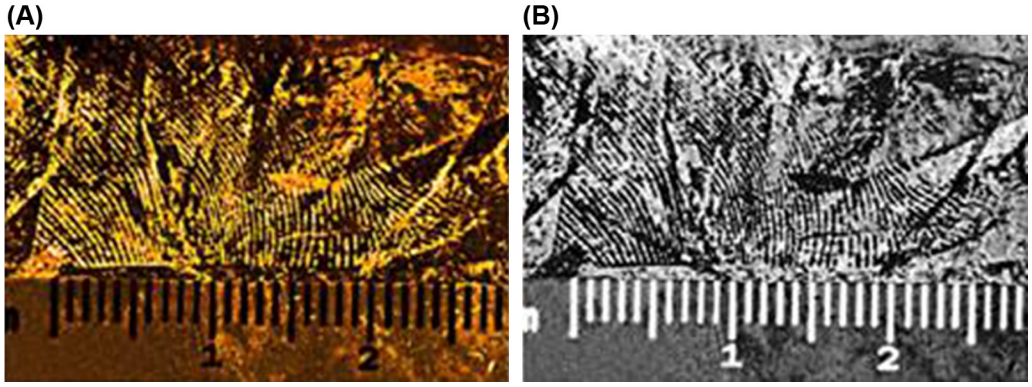


FIGURE 1.14
(A) Digital photography or laser dye-stained latent print photographed with a Nikon D200 DSLR. (B) The same photograph after processing in Photoshop to convert to grayscale and then using curves to invert the tones and adjust the contrast.

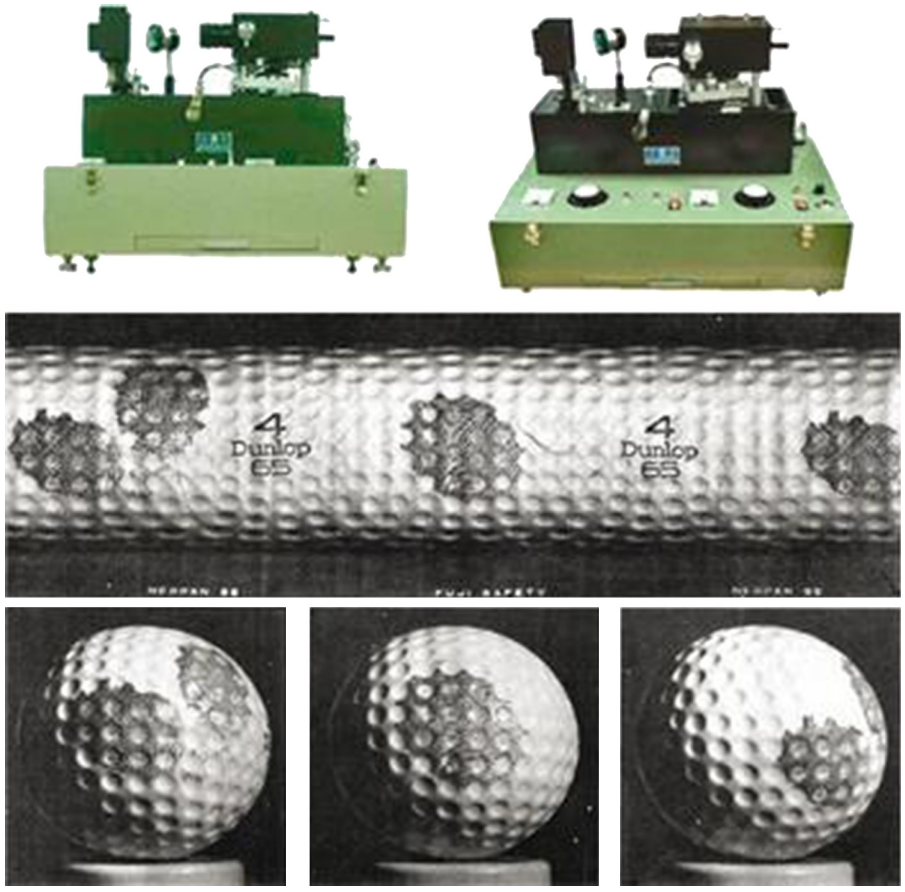


FIGURE 1.15
A 1980s Japanese latent print peripheral camera that was still sold in Japan in 2009.
Photograph courtesy Takehiko Nagasaki, Police Science Industry, Ltd.

personal computers became available that were powerful enough for digital imaging (Miller, 1998, p. 4). This point is important because this is the beginning of price reductions of PC-based digital image processing and video nonlinear systems, to the point that police agencies could start to afford them. There is no documentation for this, but based on equipment demonstrations at IAI conferences, this also was the time period during which digital photography became a third major change in mug shot photographs. The 1980s also saw the development of a peripheral camera using 120 roll films to photograph latent prints on circular objects approximately 0.2–1.5 in (see Fig. 1.15). This camera is still being sold the last time I visited Japan in 2009. The principle is very simple, yet it requires precision parts. The camera is basically a slit camera with a high-quality macro lens. When setting up the camera, you select a spindle with a top with approximately the same diameter as the evidence. This spindle combined with a matching gear ensures that the file is moved past the slit in sync with the rotation of the circular evidence. This results in a photograph of the latent prints on the entire surface of the evidence just as if you had photographed a flat object. Although I do not know of it being used in law enforcement, there is an accessory for the better light scanning back to do this same thing digitally. The year 1982 was an important year for software with the release of Media Cybernetics Image Pro Plus and the founding of Adobe (Media Cybernetics, http://www.mediacy.com/index.aspx?page=About; and Wikipedia, http://en.wikipedia.org/wiki/Adobe_Systems). The year 1985 ushered in some important software, hardware, and photogrammetry-related developments. Microsoft Windows version 1.01 was released (PC Magazine, http://www.pcmag.com/slideshow/story/336386/a-visual-history-of-microsoft-windows/2). 3-D scanners incorporated lasers to create point clouds from which an accurate graphical representation could be reproduced from the area being scanned (Artescan Blog, http://artescan.net/blog/3-d-laser-scanner-history). The camera lens autofocus technology was invented by Leica (Rockwell, http://kenrockwell.com/tech/nikon-vs-canon.htm). This is the beginning the evolution of digital photogrammetry which is Konecny's fourth and final photogrammetry development cycles (Curtin University, https://spatial.curtin.edu.au/local/docs/HistoryOfPhotogrammetry.pdf, pp. 3 and 4). Canon broke ranks in 1987 when it introduced the EOS camera lens mount (Rockwell, http://kenrockwell.com/tech/nikon-vs-canon.htm). At first, I thought this was stupid because now all my friends with 35 mm canon SLRs had to buy an entire new lens system

in order to upgrade to a newer model Canon EOS SLR. At the same time, Nikon stayed with the basic elements of their bayonet lens mount. In retrospect, Canon may have made the better decision because this change allowed Canon to overcome some design issues with the previous lens mount. With a Nikon DSLR, I can use almost any lens that was originally made for a Nikon 35 mm SLR. However, there may be some serious limitations. With a Nikon D200, there is a motor built into the camera body so that my older Nikon autofocus lenses can still autofocus. But, with a Nikon D-5000, the older autofocus 35 mm lenses can only be manually focused because there is no autofocus motor in the camera body. This is far more than just trivia. It has a practical impact on the cost benefit analysis made to determine if it is more cost-effective to stay with the same brand of camera or to migrate to a different brand when upgrading your camera system. Also, Nikon's in-camera autofocus motor tends to be slower than the autofocus motor build into more recent Nikon autofocus lenses and all current Canon autofocus lenses for their DSLR's. The 1989 Kodak D-5000 DSLR is reported to contain the basic design features upon which all current DSLR's are based (McGarvey, 2004).

A significant court case was handed down in 1987 related to photographic comparisons. The US v. Alexander was important because the court ruled that the exclusion of expert testimony by an orthodontist based on a photographic comparison that the defendant was not the person depicted in the bank surveillance film was reversible error (Scott, 1969, pocket part p. 154).

In 1989, the field saw the beginning of a new group at a symposium in Las Vegas that is more professional think tank than professional organization. The resulting technical working group evolved in 1998 into the Scientific Working Group on Imaging Technologies (SWGIT). In 2001, SWGIT added a video subcommittee. The SWGIT mission is to facilitate the integration of imaging technologies and systems within the criminal justice system CJS by providing definitions and recommendations for the capture, storage, processing, analysis, transmission, and output of images. SWGIT had approximately 28 voting members representing law enforcement–related agencies from federal, state, municipal, and foreign governments in addition to nonvoting associate members representing academic institutions and corporations with crime laboratories and invited guest experts. SWGIT was disbanded in 2015 after the formation of the Organization of Scientific Area Committees (OSAC) was formed by the National Institute of Standards and Technology (NIST) in 2014. The Video/Imaging Technology and Analysis Subcommittee (VITAL) of the OSAC's Digital/Multimedia Scientific Area Committee covers the scope of topics previously covered by SWGIT. However, until VITAL guidelines and standards are published, it is recommended that the relevant SWGIT guidelines be followed.

By the late 1990s, professional organizations were starting to have an impact outside the forensic science professions. For example, the 1997 IAI Resolution 97–9 has been cited by several courts as evidence of professional acceptance of digital imaging in the forensic science community as a scientifically valid technology that is "dependent upon the technical specifications of the equipment, the quality control procedures, and the training, experience, and ability of the photographer or imaging specialist." (See State of Washington v. Hayden, 950 P.2 d 1024 (Washington Court of Appeals, 1998) related to general acceptance within profession, and see State of Florida v. Reyes (Circuit Court of the 17th Judicial Circuit, Broward County, FL, 2002) related to digital image enhancement not new and novel.) This resolution was drafted after the Frye case and before the Daubert case to cover what is referred to as Frye hearing issues. It does not cover the Daubert issues outlined by Moenssens: proof of testing of the basic underlying hypothesis upon which the technique rests, peer review and publications, knowledge of potential error rate, the existence of an accepted methodology, and general acceptance of a technique in the forensic community. Another example of impact outside the profession is the 1999 formation of the Consortium of Forensic Science Organizations (CFSO), which was organized to inform the United States Congress about the need for passing and funding the National Forensic Science Improvement Act (Cloverdale Act) to provide funding to state and local crime laboratories in addition to the federal funding available for DNA. This included holding several science fairs in the Senate office building to showcase the disciplines in a crime laboratory in addition to DNA and what these disciplines do for the law enforcement community.

In addition to developments in digital still photography, the 1990s and the first decade of 2000 saw many new developments of significance in crime scene processing and technology for courtroom presentations. Photoshop version 1 was released by Adobe in 1991 only on the Macintosh (Wikipe-dia, http://en.wikipedia.org/wiki/Adobe_Photoshop_version_history). At this time the main option for PC users was Photostyler which was developed by Ulead and in 1992 sold to Aldus (Wikipedia, http://en.wikipedia.org/wiki/Aldus_PhotoStyler). The year 1992 was an important year for Kodak DSLRs with the introduction of IR, monochrome, and color versions of the Kodak DSC200 DSLR (McGarvey, 2004). In 1992, according to CAD Zone, they developed the Fire Zone CAD program, which is representative of some of the current crime scene sketching programs; in 1995, they developed the Crime Zone CAD Program for crime scene sketches. What has become significant is that programs like Crime Zone can now be linked

to the output from some laser crime scene–mapping systems, a bluetooth link to some laser distance measurement devices and automated panoramic camera systems like the pan-and-scan system (developed in 1999) to create a crime scene sketch. At least one vendor has an automated panoramic crime scene camera that will create a **QTVR** QuickTime file that is linked to an automatically created crime scene sketch and will show the field of view of the QTVR QuickTime image in the sketch. At least two of these systems also have incorporated a photogrammetry capability. The year 1993 marked the beginning of what would evolve into the Leica Geosystems 3-D laser scanner that by 2012 was being used worldwide by many law enforcement agencies. In 1993 was when Cyra Technologies developed the first 3-D laser scanner and point cloud software (Artescan, http://artescan.net/blog/3-d-laser-scanner-history/). Leica Geosystems purchased Cyra Technologies in 2001 (Artescan, http://artescan.net/blog/3-d-laser-scanner-history/) and the rest is 3-D laser scanner history. While 3-D scanners and panoramic cameras show a wide field of view of the surroundings, a peripheral or roll-out camera photographs the surface of an object as if the surface of the object had been rolled out flat to be photographed. Based on the US Patent, the year 1993 appears to be when Lawrence Turner Pippin invented a manual peripheral camera stand that can be used with both film and digital cameras (Artescan, http://artescan.net/blog/3-d-laser-scanner-history/). A workshop on the Rotorgraph was held at the 1997 Annual IAI Educational Conference in Danvers, MA. In 2007, a new method for combining a series of digital photographs to create a peripheral photograph of latent prints on cylindrically shaped objects (Chaikovsk, 2007). Unfortunately, the film-based and digital roll-out photography systems are still not widely used for latent print photography because of their high cost and limited use to photograph latent prints on curved surfaces. This was also the fate in the United States of a little known film-based roll-out photography camera made in Japan by the Police Science Industry, Ltd (Fig. 1.15). In the 1980s it sold for about $15,000.00 and is still sold in Japan the last time I was there in 2009. However, based on the digital evidence peripheral camera that was show in the vendor area at the 2014 IAI Annual Educational Conference in Minneapolis, MN, this could be changing. Now going back to the evolution of software, 1994 was a significant year. Adobe purchased Aldus (Wikipedia, http://en.wikipedia.org/wiki/Adobe_Systems), discontinued PhotoStyler, and released Photoshop 3 on both the Macintosh and the PC (Wikipedia, http://en.wikipedia.org/wiki/Adobe_Pho-toshop_version_history). By 1995 the Apple Quick Time Virtual Reality (QTVR) had been developed (Wells et al., 2007). This is the software that basically started the virtual tour capability as we know it today. At this time the QTVR MOV file was the main virtual tour file format. The year 1996 ushered in the PC TWAIN standard, which provides a common software link with many imaging applications and imaging hardware (McGarvey, 2004). The odd thing is that the PC Twain standard is not installed automatically when you install Photoshop Versions 4 through at least CS6. The PC Twain standard file for Photoshop is located in the Photoshop Goodies folder and has to be manually copied to the correct subdirectory. This is important because the software Photoshop plug-ins for some digital cameras and almost all consumer grade flatbed scanners require that the PC Twain standard file be installed.

In the first decade in 2000, there were many rapid advances in both software and hardware. In 2001 Microsoft Windows XP was introduced and is still in use through 2015 even though Microsoft has discontinued support on Windows XP. There are several reasons why an agency may want to keep a Windows XP computer operational. First, it is that some software is incompatible with later versions of the Windows operating system. This can be a very expensive problem if you have custom software that has to be rewritten. This may be especially true for the proprietary video players for older digital CCTV systems that may still be needed as evidence. Second, there may be hardware for which the drivers are not available for later versions of Windows. In terms of storage devices (hardware), you have a **Data Migration** cost to consider. Data that is stored on discontinued Windows XP compatible devices may have to be copied (migrated) to newer storage devices that are compatible with the newer Windows operating systems. The Foveon sensor was released in 2002 (Canon Digital Camera Blogspot, http://canondigicamera.blogspot.com/2011/03canon-digital-camera-history.html. This sensor was unique in that like color negative film, it had three light-sensitive layers. The significance is that because each pixel recorded red, green, and blue light, it did not need a blurring filter to reduce the moiré pattern sometimes created by sensors with a bayer filter array. However, the one brand of DSLR with this sensor has not been widely used by law enforcement. The first Canon DSLR with a full frame sensor was released in 2002 (Canon Digital Camera Blogspot, http://canondigicamera.blogspot.com/2011/03canon-digital-camera-history.html). The practical impact is that, in general, full frame sensors have less image noise because they have a larger pixel size. On the software side, if you still have the old licensed copy of the 2002 Version 7 of Photoshop (Webdesigner Depot, from http://www.webdesignerdepot.com/2010/02/20-years-of-adobe-photoshop/) and you process and photograph latent prints on currency, you may want to keep it because this is the last version that did not include the counterfeit deterrence system (CDS). The box version of the 2003 Photoshop CS (version 8) did include the CDS (PS2). The individual box CS version also introduced Internet activation, while the volume license copy

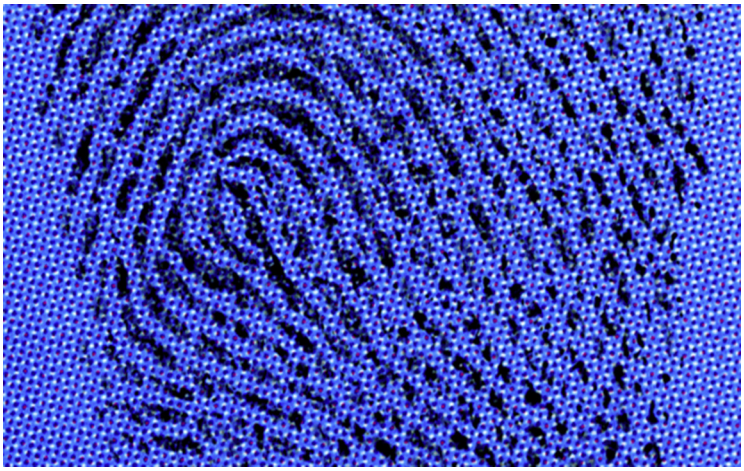


FIGURE 1.16
This is a latent print on a blue-and-white pattern.

had a real serial number that did not require Internet activation. Corel's 2004 purchase of PaintShop Pro from Jasc Software (Princeton University, https://www.princeton.edu/~achaney/tmve/wiki100k/docs/Corel_Paint_Shop_Pro.html) gave Corel a viable alternative to Photoshop. Also, Corel still sells both a licensed version and subscription version of PaintShop Pro, while Photoshop is now only available by subscription. The 2007 Fuji FinePix IS Pro UV/IR DSLR was used by many law enforcement agencies (Wikipedia, http://en.wikipedia.org/wiki/FinePix_IS_Pro). However, with the 2014 announcement that Fuji would no longer sell a UV/IR DSLR, the crime scene photography option was a DSLR camera UV/IR conversion from a third party such as LifePixel (www.lifepixel.com) or LDP LLC (www.maxmax.com). However, this changed in 2015 with the introduction of a new Fuji UV-IR camera. The 2008 DraganFlyer X6 6 rotor helicopter and Sony 20 MP camera is being used by many law enforcement agencies (Draganfly Innovations, 2014). Government regulations are still is a state of flux. Users will need to be properly trained, and there must be a written policy on their use to include relevant regulations, search warrant requirements, privacy concerns, flight time limitations, safety concerns, and no-fly zones. In 2008 Alex Chirokov released a 32-bit-FFT plug-in for Photoshop (see Figs. 1.16–1.18). This FFT plug-in was updated to a 64 bit version by Phil Thornton in 2011. Near the end of the decade in 2009, Apple dropped all support for Quicktime VR with the release of version 10 of Quicktime (Z360, http://www.z360.com/blog/?p=82). So if you have any virtual crime scene tours in a quicktime MOV file format, you either have to have an older version of quicktime or a third party player to view your virtual crime scene tour.

Additional significant court cases continued to be handed down in the 1990s and 2000s. In general, these cases reaffirmed the general foundations for videotapes and photographs used to demonstrate the testimony of a witness who has first-hand knowledge of what is depicted in the photograph or video, as listed by Miller and also stated in two unpublished memos from the Wisconsin State Attorney General's Office dated November 22, 2005. The general foundation for videotapes/digital video and film/digital photographs is that they must be relevant, must be material, must be a fair and accurate representation, and the probative value must not be outweighed by their prejudicial effect (gruesomeness or inflammatory effect) (Miller, 1998, p. 6) Although some agencies like to keep a chain of custody after converting to digital photography, there is no legal requirement to do so at this time for these photographs and videos (unpublished memo from the Office of the Wisconsin State Attorney General's Office dated November 22, 2005). For all other photographs and video recordings that are seized as physical evidence, there is a chain of custody requirement as described in detail related to video evidence and digitally enhanced digital photographs reproduced from the video evidence in the 1999 Florida case of Dolan v. State, 743 So. 2nd 544 (FL 4th DCA, 1999).

Two other issues came up in 2007. The IAI passed Resolution 2007–8, rejecting the use of **Optical Watermarks** to authenticate and/or verify the integrity of a digital photograph or video image (this resolution also defined the terms authentication and verification). Additionally, the IAI passed Resolution 2007–7, recognizing the validity of photographic comparisons and some of the limitations in this type of examination.

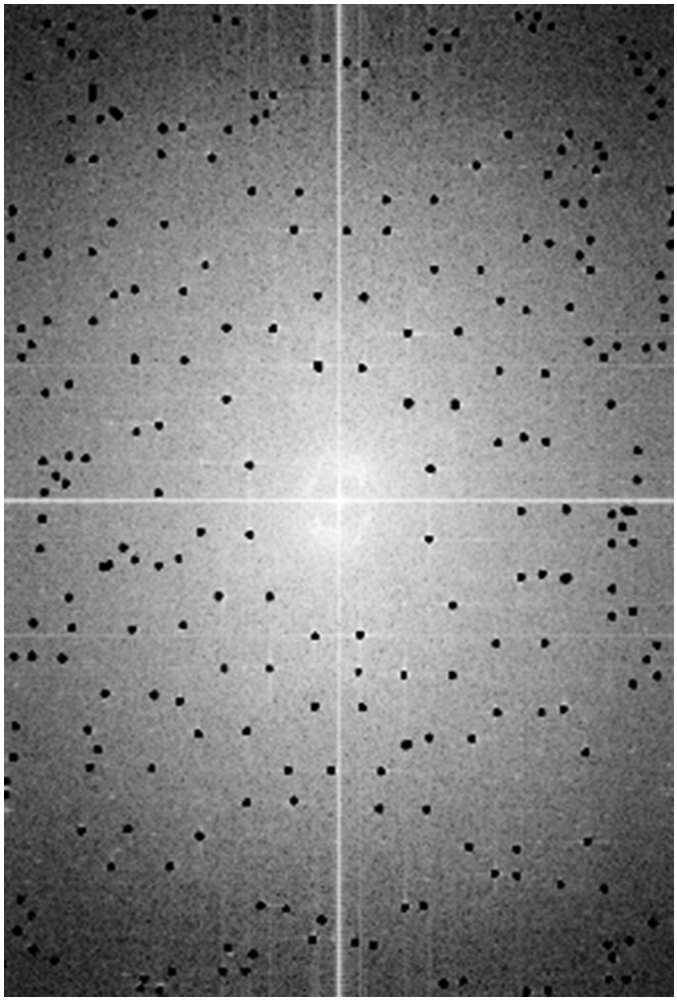


FIGURE 1.17
After applying the Photoshop FFT plug-in and blacking out the white dots that correspond with the blue and white pattern.

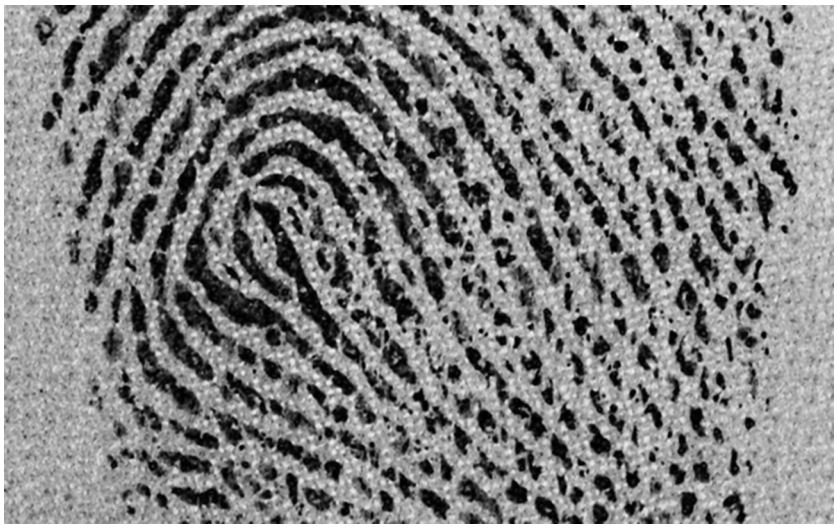


FIGURE 1.18
This is the result after applying the Photoshop inverse FFT plug-in.

The second decade of this century is shaping up to be very historically significant for crime scene photography. In 2012 Kodak, what many of us respectfully referred to in the Luke Dey era as the big yellow box, stopped making digital cameras, and will license its name to other camera manufacturers as a part of its reorganization under bankruptcy protection (Kodak, 2012). The DJI Phantom quadcopter with a GoPro camera was introduced for under $2000.00 (Braun, 2014, p. 14). When I attended the first class at Photoshop World at Mandalay Bay in Las Vegas in 2013, I was able to learn how to fly this helicopter better than I could fly a traditional two rotor design after over 40 h. By this time an updated GPS circuit with a return home capability had been added to prevent the lost of the DJI Phantom if it lost contact with the controller. Also, the quadrotor design was much more stable in light winds as compared to the two rotor design. The Canadian Draganflyer model X4-ES quadcopter with a Sony 20 MP camera (see Fig. 1.19) was released and is currently being used by law enforcement and emergency services agencies in North America and Australia (Draganfly Innovations, 2014). By 2015 it is predicted that several photography drones will be available for under $2000.00 (Braun, 2014, p. 16). It will be sometime in 2015 or 2016 before the FAA in the United States issues regulation covering the use of photography/video drones (Braun, 2014, p. 16). Although photograph/video drones have been around for decades, this is relatively new technology for law enforcement agencies. Regardless of the RC helicopter, if you plan on purchasing and using one, you need to include and budget for training, a case to carry everything in, at least one set of spare batteries for both the helicopter and the controller, and at least one set of spare rotor blades. It may be a wise investment to get a small quadrotor (approximately $100) for initial training and practice. You need to keep up with current flight regulations in your jurisdiction to include knowing where the drone no-fly zones are and who has to be notified when you are using an RC helicopter. You also needed to check with your local prosecutor about any legal requirements, such as when or if a search warrant is required and/or any potential liability issues. The year 2013 also saw the introduction of consumer VR cameras such as the Ricoh Theta (see Fig. 1.20) for under $400 that can be controlled by an iPad or iPhone. A newer version was introduced in 2015 with higher resolution for VR images and video, improved low-light sensitivity and improved video recording. Although the image quality is not that great, because of their small file size and being able to have a VR image within 3 min after you set it up, it could be useful for interviews, briefings, and limiting the number of persons who have to enter the scene to view it.

The year 2014 also marked a major change in the sale of Adobe Photoshop when Adobe announced that Photoshop would only be sold by monthly subscription. However, even though it is not being updated, Photoshop CS6 Extended is still being sold. Fortunately, CS6 using the same version of Adobe Camera RAW as CC2015. Corel announced that it would still sell both a licensed boxed version and a subscription version of PaintShop Pro. According to the Corel Website, PaintShop Pro can process RAW files and uses layers. For processing RAW files there is another option called DxO Optics Pro. What is unique about this last program is that they test thousands of camera and lens combinations to create profile files which you can download. These profile files enable the program to automatically correct for lens defects. However, the download time increases as the number of profiles files on your computer increases.



FIGURE 1.19
This is a 2013 DragonFlyer X4-ES quadcopter with a Sony 20 MP digital camera.
Photograph provided courtesy of DragonFly Innovations, Inc.



FIGURE 1.20
Original Ricoh Theta 360° camera that was originally designed as a consumer camera which can provide a quick overview of a crime for under $1000 including the camera, monopod with legs and an iPad.

SUMMARY

The history of crime scene photography as a profession is still evolving and needs to be documented so that future generations will continue to have access to it. This history is important as a guide to how new technologies and software are likely to impact our profession. Also, as Ron Smith once told me and I stated earlier, "If you do not know the history of your profession, you are doomed to repeat its mistakes." For example, many people who were pushing for all types of security to include chain of custody or automated electronic tracking of some kind due to a fear of the ease of altering a digital photograph were not aware of the ease of altering film-based ghost photographs in the 1860s to commit fraud. In terms of photographic techniques, the development of the Fuji UV/IR DSLR led many law enforcement photographers new to this profession to mistakenly believe that UV and IR photography are new and novel photographic tools because they did not know that UV and IR photography had been done for years with film. A further handicap for new photographers is that many of the previously used UV and IR photography reference books have been out of print for a long time. Also, forensic video analysis was described as a new disciple; however, many of the principles of forensic video analysis evolved from the analysis of bank film, which CCTV video replaced. The main point is that knowing the history of this profession is not just an academic exercise, but has practical applications in your daily work in forensic imaging, both at the user level and for management. Although the emphasis in this chapter was on the history of the profession, it is also important for you to keep up to date with the latest developments in the imaging profession, including annual conferences and trade shows such as the combined PMA and CES, National Association of Broadcasters (NAB); major photographic trade shows in New York City; and annual conferences and trade shows held by professional organizations such as the International Association for Identification (IAI), the American Academy of Forensic Sciences (AAFS), and the Law Enforcement and Emergency Services Video Association (LEVA).

Disclaimer

The mention of any product or specific software is not an endorsement or recommendation.

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CHAPTER 2

Composition and Cardinal Rules

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Chapter Outline

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Key Terms
Cardinal Rule
Depth of Field
Hyperfocal Focusing
Isosceles Triangle
Isosceles Triangle Point of View
Lens Flare
Reciprocal Exposure
Wagon Wheel Ellipse
Zone Focusing
Hard Shadows
Soft Shadows
Full Field of View
Responsibility

Learning Objectives

On completion of this chapter, you will be able to

1. Explain how a professional photographer can use a simple point-and-shoot camera more effectively than a novice photographer can use a sophisticated camera system;
2. Explain the three **Cardinal Rules** of good crime scene photography;
3. Explain how the same subject can be composed differently in various images;
4. Explain why "fill the frame" has two aspects, including both a positive and a negative connotation;
5. Explain why good composition partly depends on the point of view of the photographer.

As a quick search into the meaning of the word "photography" will reveal, it is derived from two Greek words, "phos" (light) and "graphia" (writing or drawing). Together, they mean either "writing with light" or "drawing with light." Photography involves the creation of an image using light.

USE-ONCE CAMERA VERSUS A PROFESSIONAL CAMERA SYSTEM

A substantial amount of sophisticated equipment can be used to create some photographic images; however, it is just as possible to create many fine images with very limited equipment. Many years ago, a professional photographer issued a challenge to a nonprofessional photographer. The professional photographer stated he could produce better photographs with an inexpensive, small use-once point-and-shoot camera than the nonprofessional could create with all the camera equipment the professional carried in his three large camera bags. The result was a very confused look on the face of the nonprofessional. How could access to all the most up-to-date and expensive camera equipment, which surely included all the latest bells and whistles professional photographers are fond of, not ensure a superior photograph?

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FIGURE 2.1
(A) The front of the camera. (B) The back of the camera.

The professional photographer suggested the nonprofessional think about the challenge for a while, and then an explanation would be provided.

Even though this professional photographer was not a crime scene photographer, the reader should consider the challenge as well. This effort provides an excellent introduction to the concepts used to create quality photographs in general, and high-quality crime scene photographs in particular.

What aspect of the small inexpensive use-once point-and-shoot camera can the professional photographer utilize so effectively that the results will be noticeably better than what a nonprofessional photographer can produce with the best equipment available?

Examine an example of such a camera the professional said he could use so well. Fig. 2.1 shows an example of the front and back of such a camera that will contain the answer.

The answer to the puzzle will be an aspect of the camera some can use well but most will use much less efficiently. There is no need to examine both images with a magnifying glass because the small print does not contain the answer.

What the professional photographer was referring to was the viewfinder, the small rectangle at the top center of the back of the camera, labeled with a red "2."

COMPOSITION AND CARDINAL RULES

What is it about the viewfinder that the professional photographer can use so well? Years ago, the professional photographer provided the following answer. He said that professional photographers are much more aware of their compositions, and they take great pains to ensure that not only is the primary subject positioned as desired, but also that whatever surroundings are included in the composition are contributing to the success of images. He further explained that the snapshot shooter usually is just concerned that the primary subject is in the field of view and then happily (and naïvely) presses the shutter button.

Explaining further, the professional indicated decisions are to be made regarding both the "primary subject" and the setting or the area around the "primary subject." The first decision is determining just what the "primary subject" should be. The professional knows that any particular image best tells its story when it is limited to just one idea, with one "primary subject." If more than a single primary subject is included in an image, the viewer may become confused about the intent of the photographer.

Keep in mind that a "primary subject" does not necessarily mean a *single* object. The primary subject may, of course, be a single object, such as a gun found at a crime. A close-up photograph of the gun will include just the gun in the field of view.

However, the primary subject may also be a small area including just two aspects of the crime scene. For example, a midrange photograph is one composed to show just one item of evidence in its relative distance to a fixed feature of the scene. In the case of a midrange image, then, the primary subject includes both the item of evidence, the fixed feature of the scene, and the distance between them. Other aspects of the scene, therefore, become extraneous to the purpose of a midrange photograph and are best eliminated from the field of view to the extent possible.

The primary subject may even be a larger area, with many items within its perimeter. For example, one of the purposes of an overall photograph is to show the crime scene in relation to the immediate area around it, which helps to acclimate the viewer to the general surroundings around a crime scene. The crime did not occur in a void. In this case, the photographer should select one or several aspects of the surroundings that will help the viewer of the overall photograph grasp this relationship. This aspect can be an easily recognized building, for example, or a nearby intersection. If a crime occurred in an alley of a particular business, showing the alley and a recognizable side of the business in one photograph will suffice. If a fatal accident occurred near a particular intersection, photographs from the intersection toward the vehicles in their final position or from the vehicles toward the intersection may be all that is needed. What is important to understand and remember is that once the primary subject has been defined in the mind of the photographer, the photographer should then become very aware of everything that is *not* his or her primary subject. To produce the most successful image, the photographer should somehow maximize the view of the primary subject while at the same time minimize or exclude to the extent possible, all areas and items that are not part of the primary subject as formed in the mind of the photographer.

The primary subject can also be viewed from different distances and from different positions around it. These differences will make a huge impact on the final image. The photographer should have a particular effect in mind and then compose the primary subject in the viewfinder so the desired effect is maximized. The professional photographer may circle around the primary subject, be it an individual item of evidence or the entire crime scene, until the primary subject is best viewed and composed. This composition will usually satisfy two goals at the same time, one which can be regarded as a positive aspect and one which can be regarded as a negative aspect. (1) It will be the composition that shows the primary subject most effectively and (2) it will be the viewpoint that excludes as many irrelevant items and areas surrounding the primary subject as possible.

Composition is just one part of creating a great photograph. It may be stated that deliberate, purposeful composition is required for any successful crime scene photograph. Some stunning candid images may exist in the history of photography, but crime scene photography should not depend on such serendipity. The word "composition" suggests the intentional choosing of the image's elements, not the result of happenstance.

Some believe composition is the most important and hardest part of crime scene photography because the other aspects of photography can usually be mastered by most with little difficulty. Although many may believe this, a large amount of this text addresses those other aspects of good crime scene photography. Subtle variations of each of these aspects of photography need to be learned. What are the other concerns related to photography? Usually, before pressing the shutter button, the photographer must at least consider the following four separate issues:

1. The primary subject should be determined, and then the composition, which best captures this primary subject should be selected.

2. It is necessary to determine the proper exposure.
3. Depending on the primary subject, an optimal focusing technique should be selected.
4. The lighting of the primary subject should be determined. This may be a very different issue than merely determining a proper exposure. For example, it may be relatively easy to properly expose an image of a shoe print in dirt. But the optimal lighting of such a 3-D type of evidence suggests that using an oblique flash to highlight the 3-D pattern of the shoe print is necessary.

Good composition is a skill that can be learned. However, it may be considered an art, as opposed to the mechanics of determining a proper exposure. Learning to juggle ISO selections, shutter speeds, and f/stops to arrive at a proper exposure seems more like a mathematical problem to many, which suggests there is always one, and just one, proper exposure for any particular subject. Even this text will suggest the most effective exposure is sometimes an "incorrect" exposure. For example, if you are trying to document a witness' ability to recognize a suspect from a particular viewpoint at 10 pm, you will need to take a photograph from the witness' point of view that duplicates the lighting conditions at 10 pm, which might be thought of otherwise as an underexposed image.

How can focusing be a difficult subject? Just look through the viewfinder and rotate the focus ring until your subject becomes clear! This text will teach other focusing techniques. At times, the use of these new focusing techniques will be the only way to achieve an acceptable image.

These ideas suggest that good photography involves both mechanical skills and an artistic component. Photographic lenses, as variations of imaging optics, like telescopes and microscopes, can be considered a scientific tool. Viewed as dealing with an artist's creation, photography can be considered an art. Just as it is relatively easy to play chess with a nephew or niece, chess can be played on many different levels. Most of us easily learn how the different chess pieces can be moved. Becoming an expert at chess, however, requires more than simply understanding how individual chess pieces move. Many can learn how to balance shutter speeds and f/stops to determine a proper exposure. Developing a photographer's eye and becoming very good at photography are not as easy. Two views of the same crime scene may call for the same exposure, but just one of the views may obviously be the better composition.

In addition to concepts related to good composition, this chapter introduces material that will be found throughout the text. This material is provided in this chapter, early in the text, because of its importance. Unfortunately, there has not been an appropriate emphasis on these concepts in other texts related to crime scene photography. Perhaps, instead of "Cardinal Rules," they might best be thought of as "tips for optimizing the quality of crime scene photographs." The Cardinal Rules can also be considered key crime scene photography concepts. Here they are

1. Fill the frame.
2. Maximize **Depth of Field**.
3. Keep the film plane parallel.

All these Cardinal Rules of crime scene photography will not necessarily apply to other types of photography. Taking photographs of loved ones or pets will not require strict adherence to all these crime scene photography recommendations. Having an understanding of their meaning, however, will often result in improved generalized photography.

Adherence to these suggestions will often be the criterion that separates the average crime scene photographer from the truly excellent crime scene photographer. You may ask how you might improve the current quality of your crime scene photography. The answer will frequently be, follow these "Cardinal Rules."

Cardinal Rule #1: Fill the Frame

If something is important enough to photograph, fill the frame with it. Follow this practice whether it is a single item of evidence or a specific area of the crime scene. Too many times, the primary subject can get lost in a confusing mix of elements. If these otherwise irrelevant elements are not considered a part of the "primary subject," try to minimize or eliminate them.

GET CLOSER TO THE PRIMARY SUBJECT

Ask yourself, "Can the primary subject, or the scene of interest, be made bigger by getting closer to it?"

1. Put as many of your sensor's digital pixels as possible over the primary subject.
2. Get closer to eliminate unwanted or unneeded areas/objects around the primary subject.



FIGURE 2.2
(A) Pistol not filling the frame. (B) Pistol filling the frame.
GWU MFS Student D. Schweizer.

Fig. 2.2 are intended to be close-up images of a pistol. Notice in Fig. 2.2A that there is a lot of grass included in the image, when the purpose of the photo was just to photograph the gun. Fig. 2.2B succeeds in two important ways: The gun is larger, so it is easier to see; in addition, there is less irrelevant grass in the image. Why waste image area and digital pixels on irrelevant subject matter? Doing so only detracts from the main purpose of the image. It is also a signal to the viewer of the photograph that the photographer is probably naïve about the importance of using the work space of the photograph to its best advantage.

Other times it may be important to show a gun in relation to the victim or a fixed feature of the crime scene. This is called a midrange photograph. In that case, what is the primary subject matter of this new photograph? It is the gun and the fixed feature of the scene (or the victim's hand, for example) and the distance between the two? The question then becomes, how can you best compose this image, including both the gun and the fixed feature of the scene? Make the pistol as large as possible, while at the same time eliminating as much irrelevant surrounding clutter as possible from the composition. The midrange photograph has one job to do. Let it do just that job.

Overall photographs show a larger area around the gun and a fixed feature of the scene. They are also necessary photographs in the full documentation of the crime scene and the evidence within the scene; however, different photographs serve different purposes. Once you have that one purpose formed in your mind, compose the shot accordingly. The purpose of each of the images in Fig. 2.3 was to show the gun in relation to a fixed feature of the scene: in this case, the corner of a cement slab. Which image does that job better? Which composition has the primary subject matter (both the gun and a cement corner) larger and easier to see? Which composition excludes nonessential detail? Which photograph indicates the photographer had a clear purpose and knew how to eliminate irrelevant subject matter? Clearly, Fig. 2.3A succeeds in all those areas.

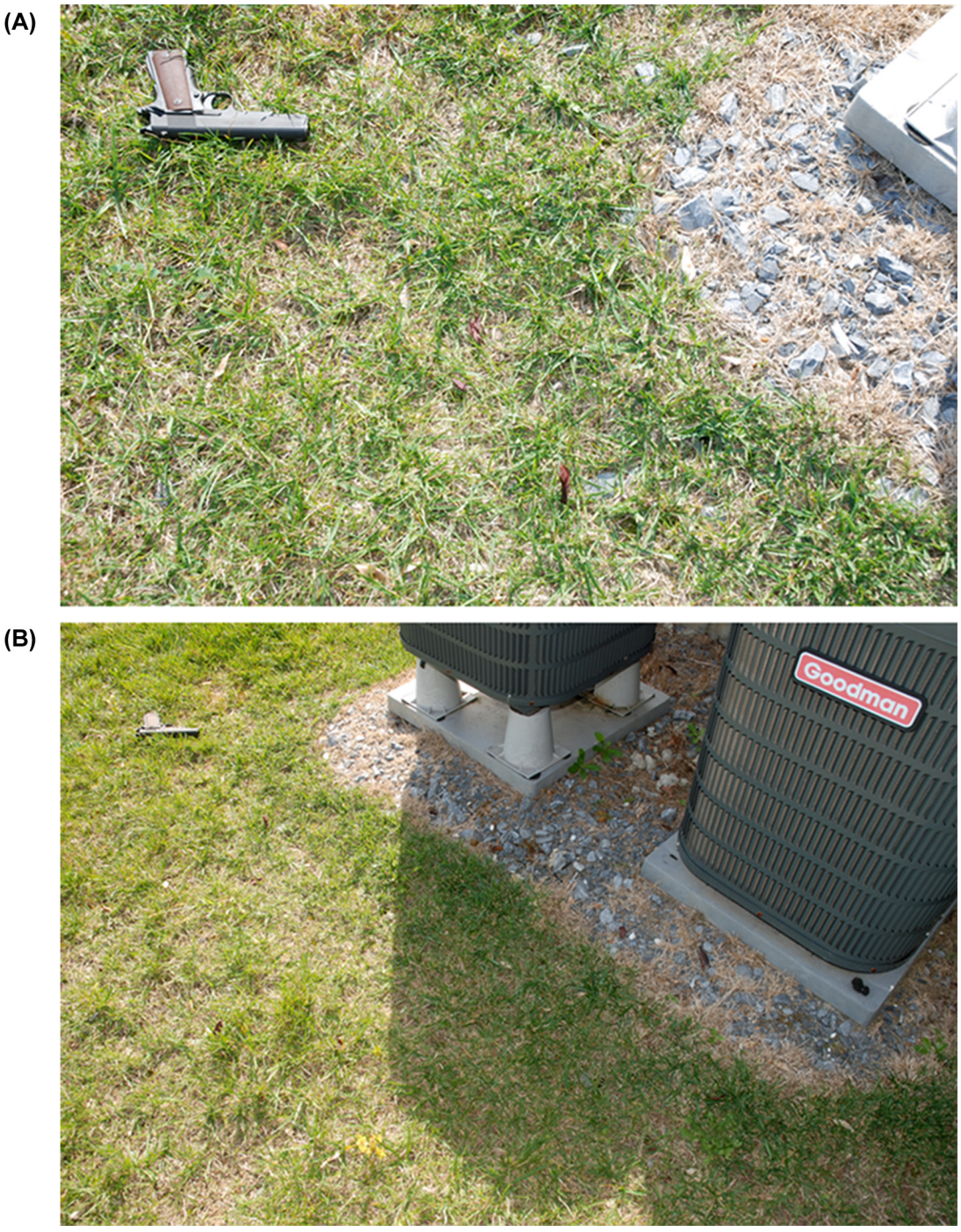


FIGURE 2.3
(A) Proper midrange. (B) Too much included!.
GWU MFS Student D. Schweizer.

3. If the subject is longer than it is wide, and most items are, compose it with the appropriate horizontal or vertical camera viewpoint. If it is longer left-to-right, use a horizontal viewpoint; if it is longer from near-to-far, use a vertical viewpoint.
   The images in Fig. 2.4 are both close-up photos of a knife. Is one preferable? This author hopes you will agree that the Fig. 2.4B is the better image on two counts. First, the knife is larger in Fig. 2.4B, and second, there is less carpet showing in it. Fig. 2.4B has more digital pixels covering the actual knife; why put them anywhere else?
4. Avoid, however, having the primary subject so close to the edges of the photograph that parts are cut off in the print. Do not overdo the aspect of "filling the frame." Fig. 2.5 fails on two counts. First, the rifle should have been composed positioned left-to-right in the image rather than vertically. Second, some of the stock has been cut off by getting the camera too close to it.

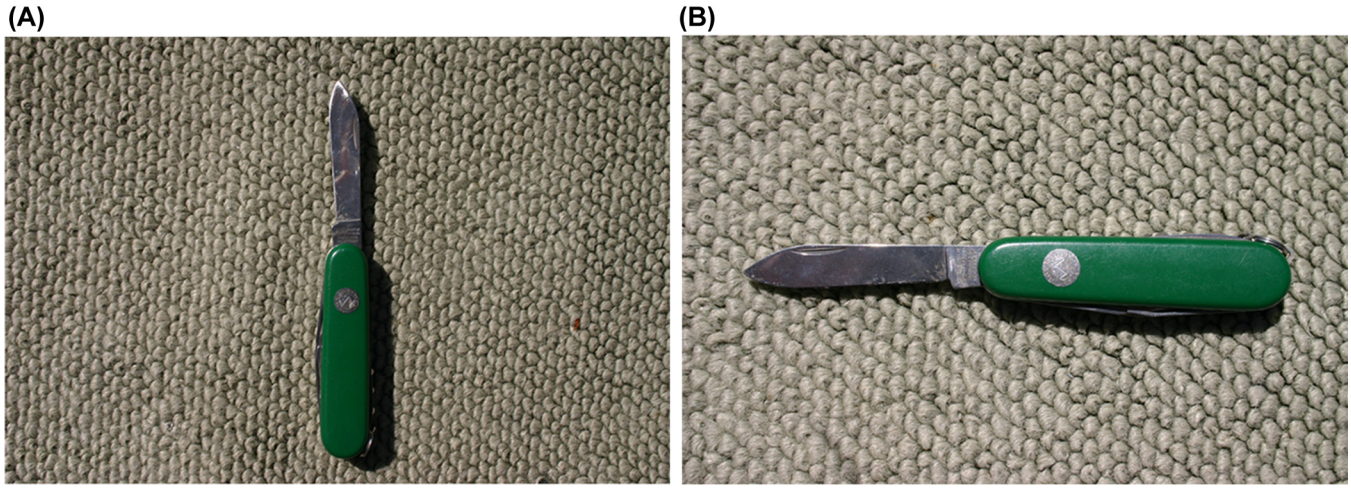


FIGURE 2.4
(A) Camera should be vertical or the knife should be composed horizontally. (B) Proper composition.
GWU MFS Student B. Reilly.



FIGURE 2.5
Improper composition (GWU MFS Student D. Schweizer).

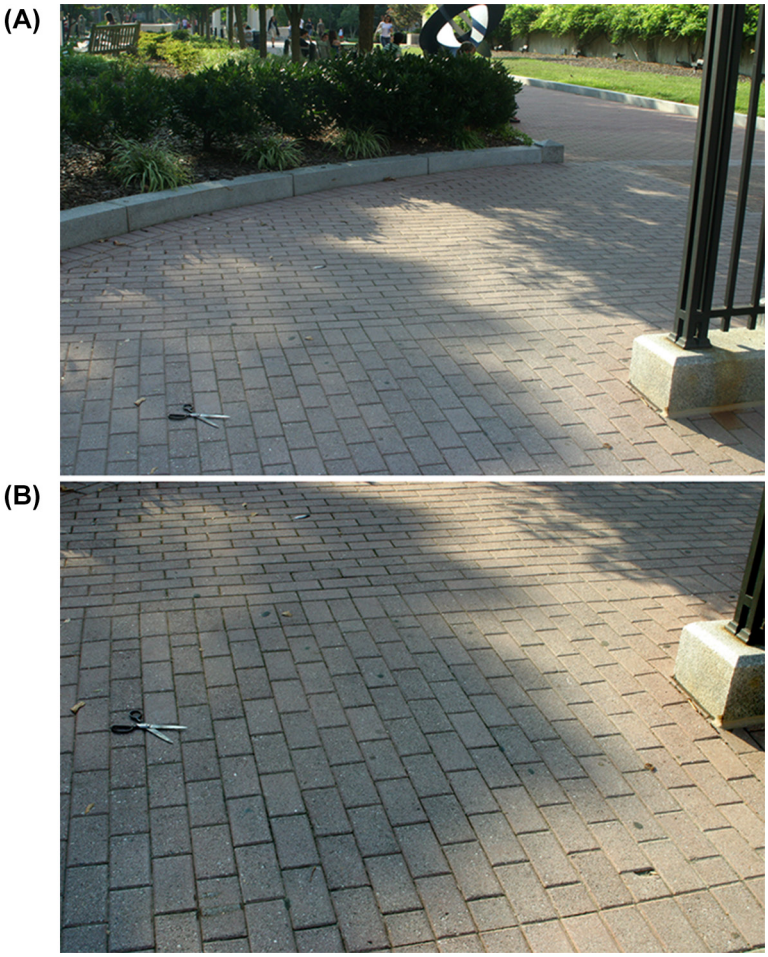


FIGURE 2.6
(A) Too much showing in the background. (B) Lower the camera and get closer, and this is the result.

ELIMINATE THE IRRELEVANT

Ask yourself, "Is there any part of the composition that can be eliminated to make the overall photo better?"

In the Background

1. You will be a better photographer if you hold yourself responsible for what appears in the background. The viewer of your photographs should be able to presume that if anything appears in the background, it is there because you wanted it there.
2. If you do not like what you see in the background, choose another viewpoint that has a "cleaner" background. You may circle the subject until the background has fewer or no distracting elements in it.
3. At times, you may also consider providing your own backdrop that prevents a view of a distracting background. This topic will be revisited in another chapter.
4. Another way of eliminating distracting backgrounds is to tilt the camera down more. In doing so, you may compose the distracting background out of the photo. Take, for example, the two images that are shown in Fig. 2.6. They are supposed to be examples of a midrange photograph. It can be presumed that overall photographs, showing the crime scene in relation to the surrounding area, have already been taken. Therefore, it is not necessary for the midrange photograph to do this job. Midrange photographs have their own specific job to do.

The intent of both images in Fig. 2.6 is to show the scissors in relation to the gate support. The Fig. 2.6B contains the same details as in Fig. 2.6A; however, the Fig. 2.6B excludes distracting and irrelevant background elements. Fig. 2.6B also has both the scissors and gate support appear larger in the field of view. Why have them appear smaller than necessary? Including extraneous and irrelevant background details frequently requires the primary subject matter become smaller than necessary.

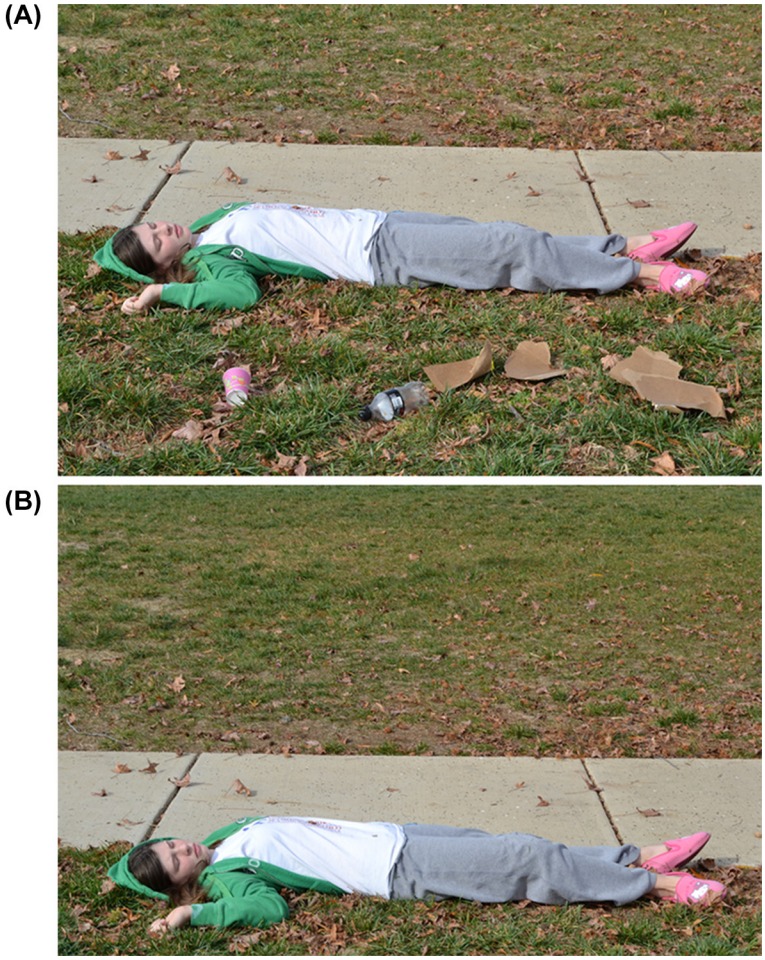


FIGURE 2.7
(A) Distracting elements in the foreground. (B) Raising the camera eliminates the foreground elements.
GWU MFS Student L Yockel.

How do these images also comply with Cardinal Rule #3 (more fully discussed later in this chapter), "keep the film plane parallel?" In this case, an imaginary line connecting the scissors and the gate base is composed to be parallel with the film plane.

In the Foreground

1. You will be a better photographer if you hold yourself responsible for what appears in the foreground. The viewer of your photographs should be able to presume that if anything appears in the foreground, it is there because you wanted it there.
2. If you do not like what you see in the foreground, choose another viewpoint that has a "cleaner" foreground. Just by moving around the subject, a better viewpoint might be found, which does not contain distracting and irrelevant foreground elements.
3. Another way to avoid distracting foregrounds is to raise the camera up a bit. This may compose the distracting foreground out of the photo.
   The images in Fig. 2.7 were taken to show the right side of a body. This is a part of the full-body panorama sequence of images. The Fig. 2.7A, however, includes some items in the foreground, which may not be relevant at all. If they are evidence, and we want to show one of them in relation to the body, that can be done in a separate image. This particular image, however, is just supposed to be the right side of the body. Let other images show other relationships. The solution, the Fig. 2.7B, provided the answer. When the camera is raised, extraneous elements are excluded from the field of view. This Fig. 2.7B is obviously composed by a photographer who is aware that a professional carefully chooses not only what to include in the field of view, but also what to exclude from it. Full body panorama images, however, have their own specific job to do. To the extent possible, let each image do its own job.
4. Or, get closer to crop out distracting or unwanted elements.

In Areas to the Left and Right

1. You will be a better photographer if you hold yourself responsible for what appears to the left and to the right of your primary subject. The viewer of your photographs should be able to presume that if anything appears on the left or right side of the primary subject, it is there because you wanted it there.
2. Use the same considerations as with the background and foreground.
3. If you want it included in the photo, include it; if not, exclude it somehow.
4. Remember, if the subject is long, compose it to fill the frame with the subject, not the surrounding area.

"Fill the frame with the primary subject" is just the positive aspect of a two-sided coin. The other side of the coin contains a negative aspect, which is "eliminate as much as possible from view if it is not the primary subject." *Include what you want; exclude what is unimportant*. Doing so will quickly separate your images from most crime scene photographs. Back to the preceding midrange photography examples: if just one item of evidence and one fixed feature of the scene are the "subject matter" for a particular photograph, include in your composition just those two items and eliminate as much as possible around them.

This author knows what you are thinking. He has also worked many crime scenes where there is so much clutter around both the items of evidence and the victims that adhering to the preceding suggestions was frequently impossible. Sometimes it will be impossible to completely adhere to these Cardinal Rules. That does not diminish their importance. Part of the purpose of this text is to help you begin developing a professional photographer's eye. Most crime scene photography will benefit from knowledge of these Cardinal Rules and their implementation. Incorporating these Cardinal Rules into your photographic method will soon be a factor in your crime scene images being recognized as distinctly superior to the average crime scene photographer's work.

Shadow Control

1. Shadows from sunlight:
   a. As you compose photos outside, try to avoid having your own shadow, or the shadows of coworkers, appear in the field of view.
   b. If it appears impossible to avoid having your own shadow appearing in the field of view, and the scene is small enough, for example a close-up photograph, attempt to reposition your body so that your own shadow *completely covers* the area to be photographed. Then, with no shadow to draw attention to itself, meter the scene completely covered in shadow and the scene will be properly exposed.
   c. Try to have the scene be completely shadow free or completely covered with shadow.

The shadowless images of Figs. 2.8 and 2.10 are preferable to the shadows apparent in their top counterparts. Knowing both pairs of images are possible, however, and the effort to create the bottom images are minimal, why not opt for these Figs. 2.8B and 2.10B? As long as you specifically meter the area covered completely in shadow, the resulting image should look properly exposed.

Fig. 2.9 shows the photographer about to photograph a shoe covered in the patterned shadow of the railing. Remembering that shadow control is the photographer's responsibility, the right image of Fig. 2.9 shows the photographer after repositioning themselves to block the sun, and then fill the frame with the shoe covered in shadow.

2. Shadows from electronic flash:
   a. The use of an electronic flash may create a shadow in your photograph, and you should also hold yourself responsible for this shadow, even if you cannot see it when the photograph is taken. You must begin to "pre-visualize" your own flash shadows. Distracting flash shadows can ruin otherwise-excellent photographs.
   b. Consider altering the position of the flash head to minimize or control the shadows within the scene. In the top image of Fig. 2.11, the photographer held the flash too far to the left and the flash caught the railing, creating an unnecessary railing shadow in the scene. The right image avoids this shadow because the photographer intentionally held the flash directly overhead.
   c. If the flash is removed from the camera's hot-shoe and connected to the camera by a remote flash cord, you may position the flash in a variety of locations. Choose the position that minimizes the resultant flash shadow.

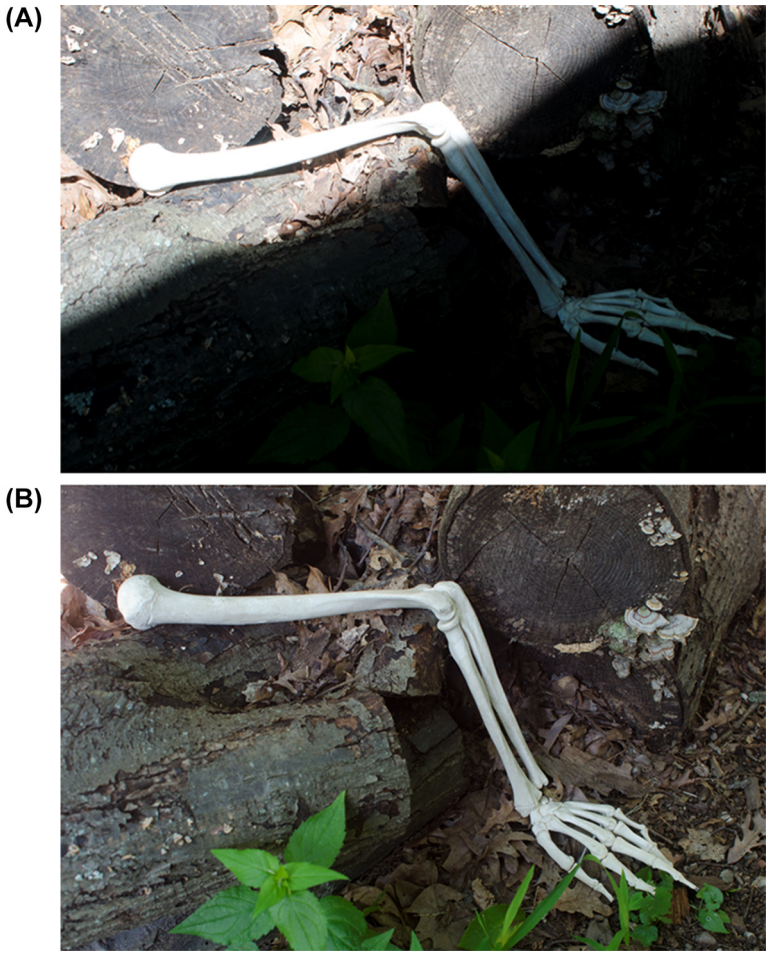


FIGURE 2.8
(A) Sunlight and shadow. (B) Sun blocked: exposed for the shadow.
GWU MS Student D. Rio.



FIGURE 2.9
Left: Improper composition. Right: Blocking the sun and exposing on the shady area.
GWU MFS Student V. Hart.



FIGURE 2.10
(A) Sunlight and shadow. (B) Sun blocked: exposed for the shadow.
GWU MFS Student D. Schweizer.



FIGURE 2.11
Left: Electronic flash creating a shadow. Right: The flash head held to eliminate the shadow.

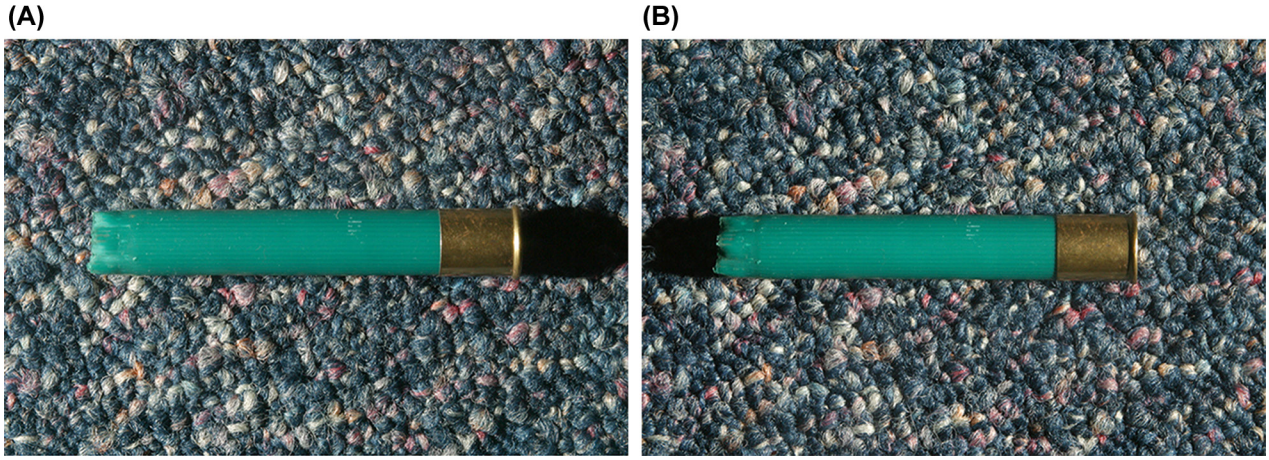


FIGURE 2.12
(A) Hard shadow on right side. (B) Hard shadow on the left side.

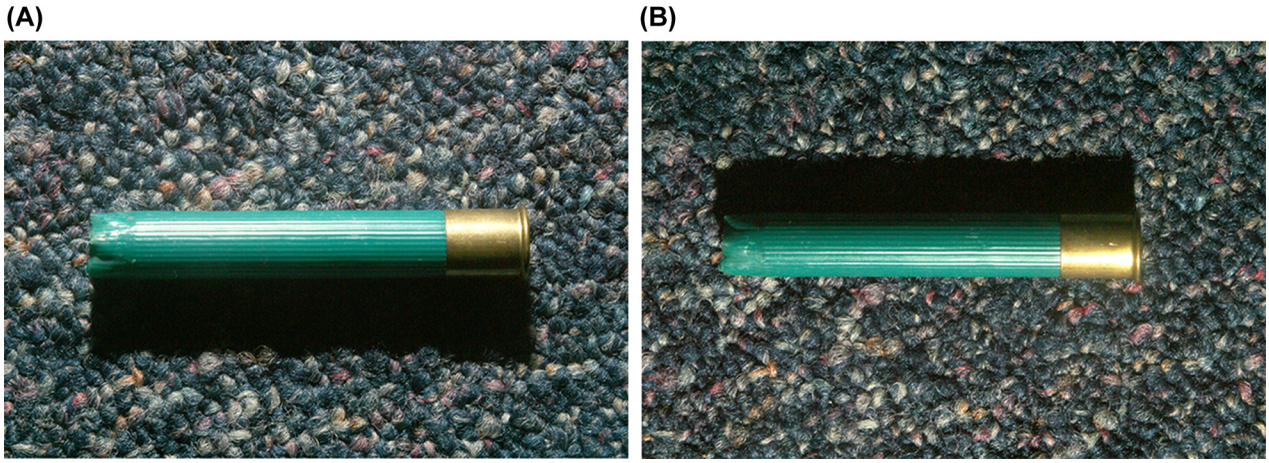


FIGURE 2.13
(A) Hard shadow on the bottom. (B) Hard shadow on the top side.

With the flash on a remote flash cord, all the shadows in Figs. 2.12 and 2.13 are possible, as well as a variety of shadows created with the flash held diagonally to the 0.410 shot shell casing. If all are possible, is one preferable? Because the shadows themselves are irrelevant to the intent of the photographer attempting to capture a close-up image of the casing, a small shadow is better than a large shadow. Of the two small shadows in Fig. 2.12, is one "better" than the other? It may be argued that the Fig. 2.12A is "better" (or, less annoying) because sometimes shadows suggest movement or directionality (the image of a speeding car with tail light streaks coming from the rear of the car comes to mind), and a shadow at the base of the casing may appear more "normal" than one at the front of the casing. If this is so, then compare the shadows in the images of Fig. 2.12A and 2.14B. Notice the difference?

The darker shadow of Fig. 2.12 is referred to as a "**Hard Shadow**." This is a shadow in which detail cannot be seen. In this particular case, since the hard shadow falls on nothing but carpeting, the hard shadow is unimportant. However, there will be times when the area of hard shadows falls within the evidence, masking part of the detail, for example, of a shoe print or tire track. In these cases, the presence of the hard shadow masking some of the detail of the evidence is critical! It is possible that details in the hard shadow areas are necessary to help make the identification between a suspect shoe impression and a defendants shoe. So, eliminating these hard shadows is extremely important at times. How is this done?

Look at the shadow in the image of Fig. 2.14A one more time. In this image, you *can* see details of the carpeting within the shadow area. This brighter shadow is called a "**Soft Shadow**." Had this shadow covered an area of shoe print or tire track, the examiner could detect details within the shadow area and use them to help make identifications. Consider both images of Fig. 2.14 once more. The soft shadow was made by using a bounce card or reflector on the side of the evidence where the shadow will occur. The reflector or bounce card bounces light into the area where a hard shadow had been. It is not enough light to overexpose the image, but it is enough light to change the shadow from and hard to a soft shadow.

d. If a **hard shadow**, one in which details cannot be seen, is created by the use of oblique flash, use a bounce card/reflector to add light to the shadow area, thereby making the shadow a soft shadow, in which details can be seen. This subject will be revisited in the chapter dealing with oblique electronic flash and oblique flashlight.

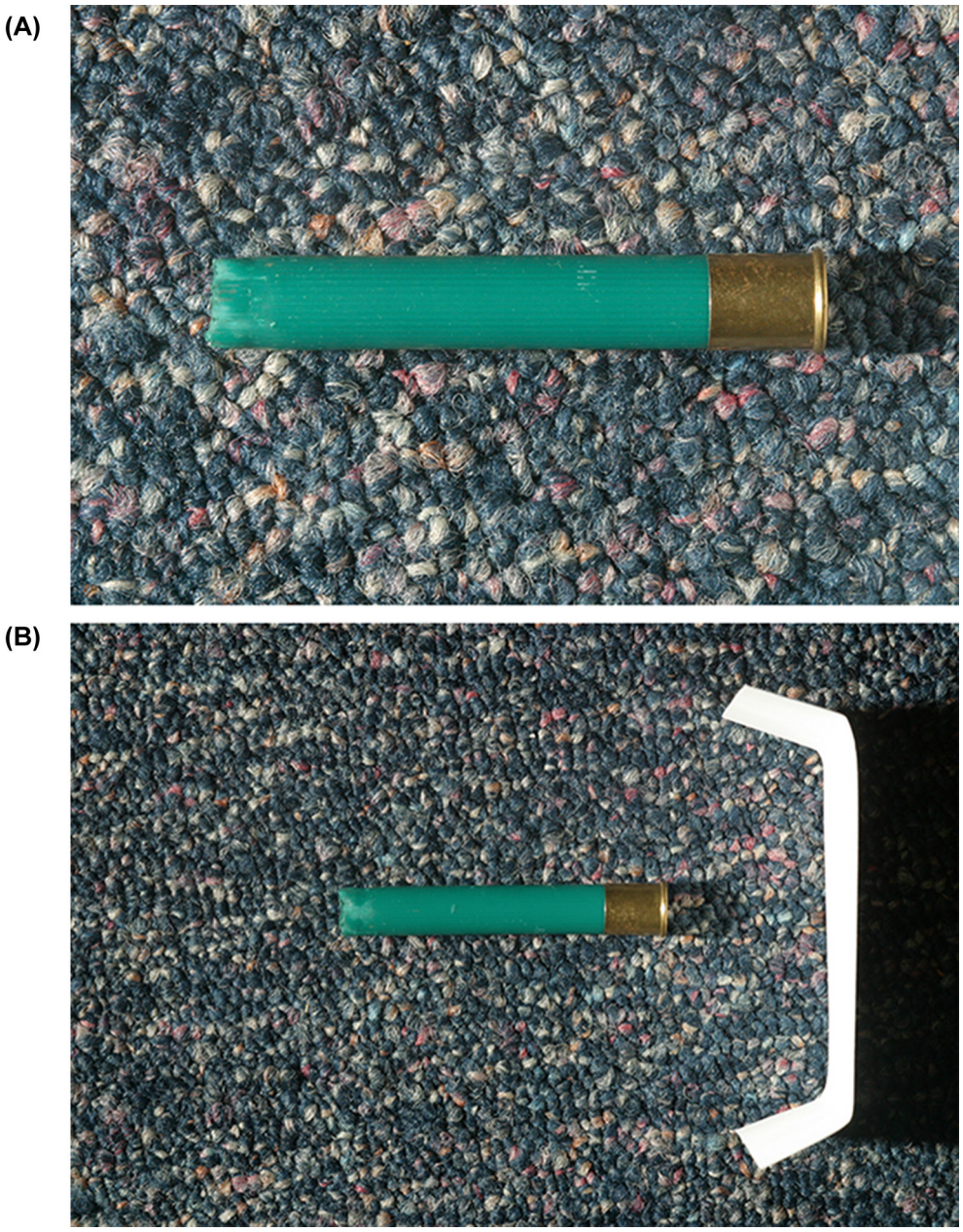


FIGURE 2.14
(A) Soft shadow on the right side. (B) Reflector creating the soft shadow.

Lens Flare

If possible, avoid taking photographs with the sun in front of you:

1. **Lens Flare** may ruin an otherwise excellent photograph.
2. Objects that are important often tend to be backlit and underexposed.

In both images of Fig. 2.15, sunlight was able to enter the lens directly, where it created images of the lens' optical elements and the aperture opening on the sensor. This is certainly distracting and detracts from the intent of the photographer. Sometime these flare elements are visible to the photographer while he or she looks through the viewfinder, and sometimes they are not. If you cannot avoid a composition that has the sun in front of you when you press the shutter button, consider using a lens hood. Fig. 2.16A shows a camera and lens, whereas Fig. 2.16B shows a camera and lens with a lens hood. The lens hood used in the image of Fig. 2.18A extends from the front of the lens, intersecting the direct path of the sunlight into the lens. Light reflected from the scene into the lens is not affected by the lens hood.



FIGURE 2.15
Lens flare.

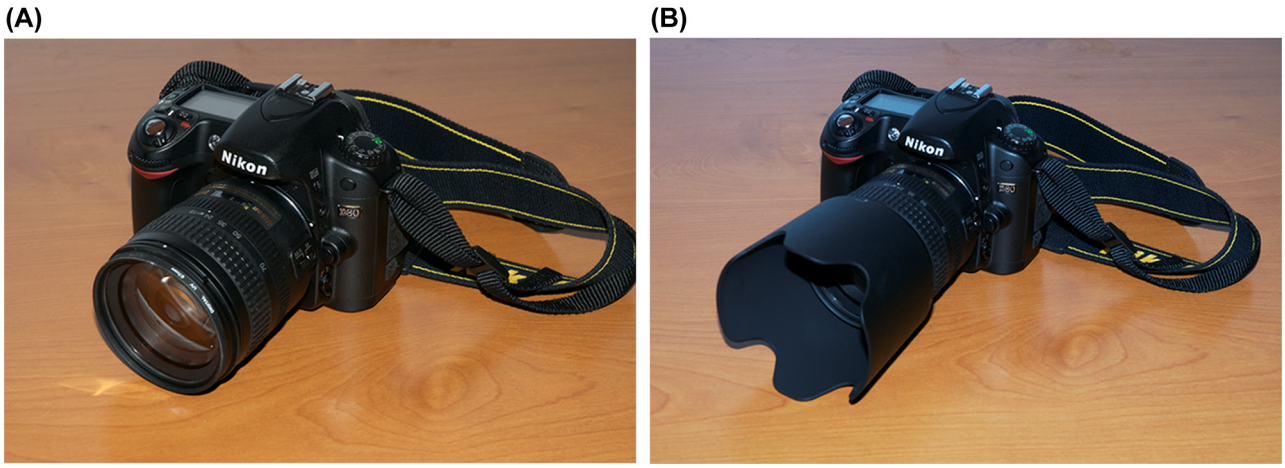


FIGURE 2.16
(A) Camera and lens. (B) Camera and lens with hood.
GWU MFS Student D. Schweizer.



FIGURE 2.17
(A) Lens flare from behind the house. (B) Lens flare eliminated.
GWU MFS Student K. Mentore.

Both images of Fig. 2.17 show a building with and without lens flare. In the Fig. 2.17A, a lens hood was not used to eliminate the lens flare. The Fig. 2.17B did have the sunlight blocked from coming directly into the lens. Fig. 2.18A shows the lens hood in use. Fig. 2.18B, shows the "poor man's lens hood." You can achieve an effect similar to using a lens hood by blocking the sun from coming into the lens with your hand. Alternately, a coworker can hold up his or her hand or a clipboard to block the sun's rays from coming directly into the camera lens.

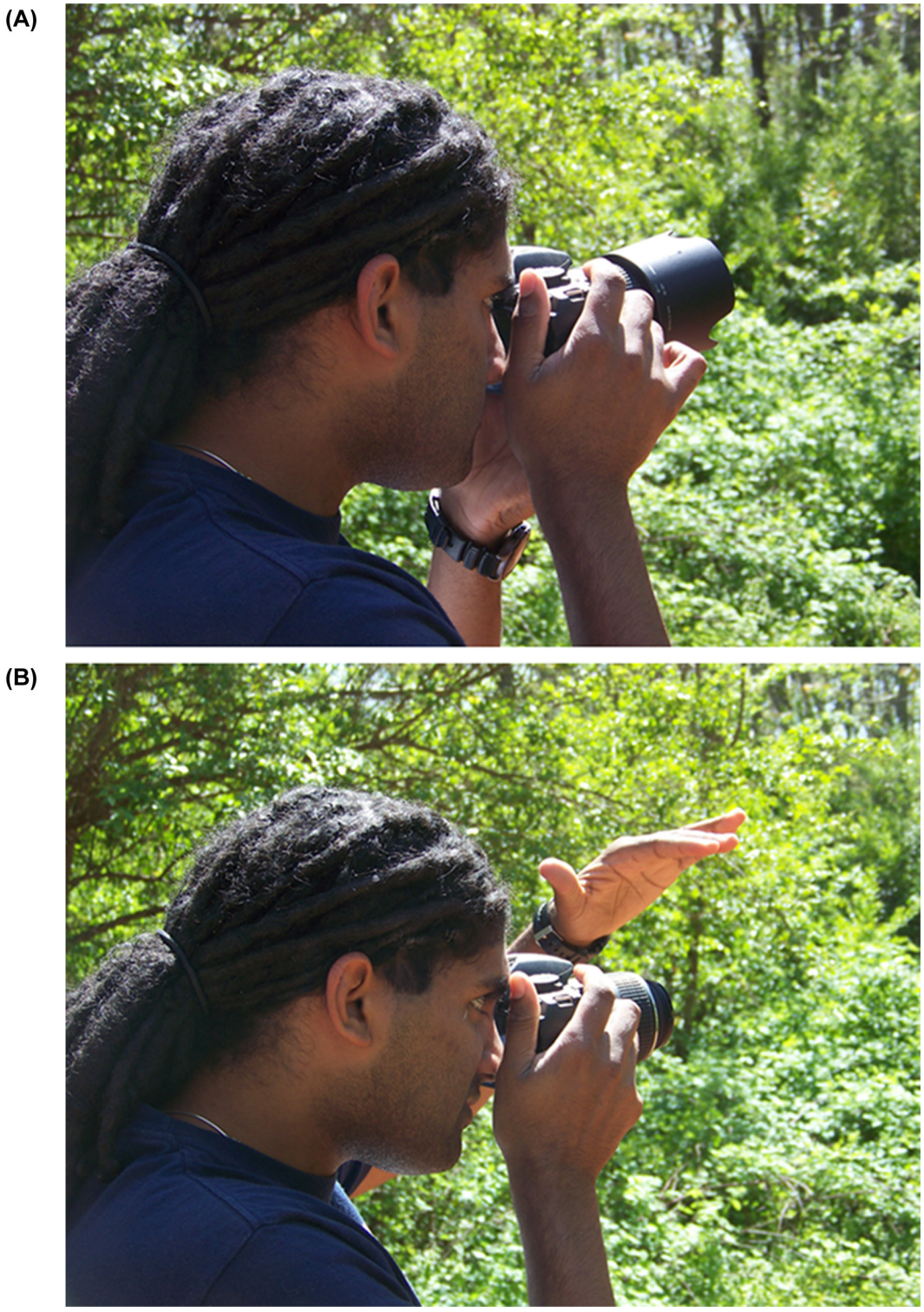


FIGURE 2.18
(A) Use of a lens hood. (B) Photographer's hand used to block lens flare.
GWU MFS Student K. Mentore.

It is very important to explain another reason to **Fill the Frame** when arranging a composition. It was previously mentioned this results in putting more pixels over the primary subject. Why not put your pixels over the evidence rather than the surrounding area where there is no evidence. The following figures will underscore that idea.

Fig. 2.19 shows a single fingerprint photographed with a macro lens set to 1:1, which fills the frame with a single fingerprint. The 1:1 setting is designed to fill the frame with an object, which is as big as the full sized digital sensor. A fingerprint is the perfect example of crime scene evidence this size. Some macro lenses also have magnification ratios from 1:1 all the way to 1:10. Think of all these ratios as fractions: a 1:1 can be thought of as 1/1, or, full sized on the digital sensor. A 1:3 magnification ratio should be thought of as 1/3; an object the size of a fingerprint will appear either to be 1/3 its normal size or three fingerprints will fill the frame. See Fig. 2.20 for an example of the macro lens set to 1:3. A 1:5 magnification ratio can be thought of a 1/5, or, a fingerprint would be captured at 1/5th its normal size. A 1:5 magnification ratio might be perfect to fill the frame with a partial palm print, if it is as wide as five adjacent fingerprints.



FIGURE 2.19
Macro lens set to 1:1 to fill the frame with a fingerprint.



FIGURE 2.20
Macro lens set to 1:3 to fill the frame with three fingerprints.

Here, it is appropriate to show an image of a macro lens, Fig. 2.21. In Fig. 2.22, that macro lens set to 1:1, 1:3, and 1:5 magnification ratios. At the left of the focusing window, there is an orange "1:" above the yellow "ft" and white "m" symbols. As the macro lens focusing ring is rotated, one can align different magnification ratios to go with the "1:" symbol. The focus point is the yellow vertical line above the "R" of "NIKKOR." The top image aligns a "1" above the focus point, for a 1:1 magnification ratio. The middle image aligns a "3" above the focus point, for a 1:3 magnification ratio. The bottom image aligns a "5" above the focus point, for a 1:5 magnification ratio.



FIGURE 2.21
A Macro lens on a camera.



FIGURE 2.22
A Macro lens set to 1:1, 1:3 and 1:5.

Fig. 2.23 shows three images of an earring clasp, designed to secure the post of an earring. The 1:1 designation relates to the fact the clasp was photographed with a macro lens set to capture a fingerprint full size on the digital sensor. Being much smaller than a fingerprint, it is not filling the frame, but the macro lens is not designed to further enlarge such a small item. The clasp photographed at 1:3 shows the clasp 1/3 the size as seen in the 1:1 image. The clasp photographed at 1:5 shows the clasp 1/5 the size as seen in the 1: 1 image. Obviously, as the clasp gets smaller and smaller, fewer and fewer pixels within the frame of each image are covering the clasp. Is that important? Each of the three images looks sharp and in focus, right?

What if were necessary to enlarge each of the three clasp images to try to visualize small detail on the clasp, which cannot currently be seen yet?

Fig. 2.24 shows the 1:1 clasp cropped and enlarged. Then, the 1:3 image of the clasp and the 1:5 image of the clasp are also cropped and enlarged to the same size as the 1:1 clasp. Now, within the three blue ovals, there are some smaller details that need to be compared. Each area within the blue ovals is enlarged to better see these details. In the 1:1 crop and enlargement, what appears to be a "star" shape has been circled in red. This same area cannot be clearly detected as a star in the 1:3 or 1:5 enlargements. Why not? Without adequate pixels covering the star shape, there is insufficient resolution to see the details still visible in the 1:1 enlargement.

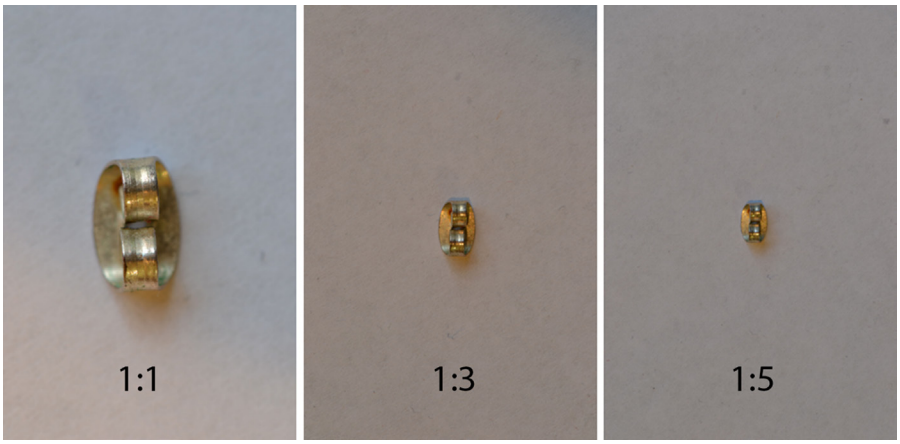


FIGURE 2.23
Earring clasps captured at 1:1, 1:3 and 1:5.

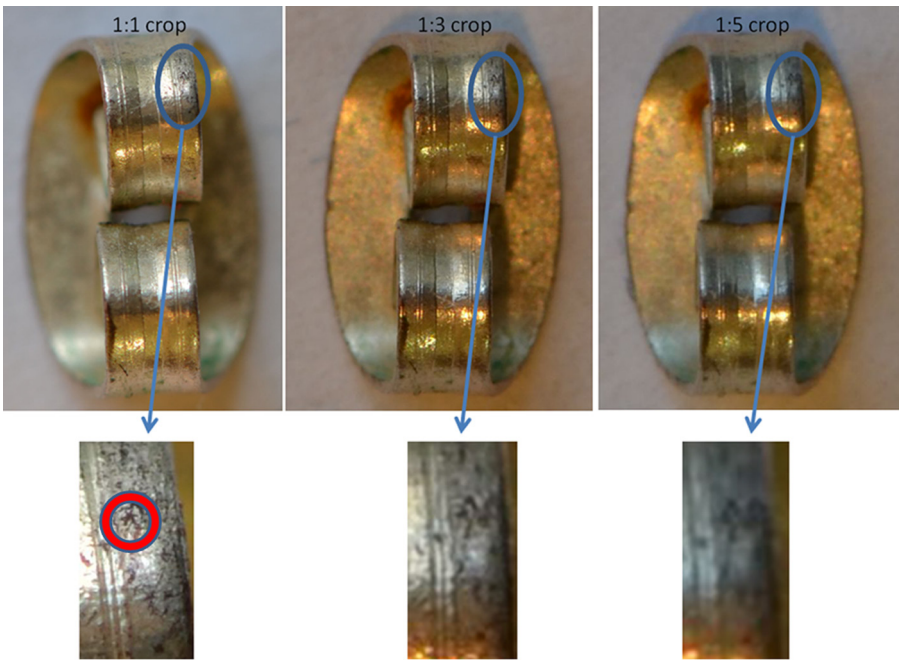


FIGURE 2.24
All three clasps enlarged to the same size, and a small area of each enlarged more.

What if that star were a jeweler's mark uniquely signifying their work, and the clasp was found in the pants cuff of a suspect arrested four blocks from a rape and homicide scene, and the victim's other earring had the same jeweler's mark? With sufficient resolution, the mark is visible and becomes critical evidence in a subsequent trial. With insufficient resolution, the connection between the two clasps cannot be established, and the prosecution of the case may be in jeopardy!

Filling the frame with evidence, or doing this as much as is possible, puts more pixels over the evidence, increasing the resolution of the evidence image, enabling the evidence image to be enlarged. Otherwise, all those pixels are over the substrate the evidence is found on, doing no one any good!

The Cardinal Rule, Fill the Frame, can be expressed another way. One can say that the photographer has a **Full Field of View Responsibility**. If crime scene details appear in the viewfinder, they should be there because the photographer intended for them to be included in a particular composition. A quick review of the elements, which comprise this responsibility, will be handy for the reader:

- Get Closer to the Primary Subject (which can be a single object, or a specific area)
- Eliminate the Irrelevant
  - In the Background
  - In the Foreground
  - In areas to the Left and Right
  - Shadow Control
  - Lens flare

Cardinal Rule #2: Maximize Depth of Field

Depth of field is the variable range, from foreground-to-background, of what appears to be in focus. This topic will be explained in detail in the chapter "Focus, Depth of Field, and Lenses", but a brief explanation of this Cardinal Rule needs to be done now. The depth of field can be very small, where only one plane or distance from the camera appears to be in focus. It can encompass a small area of the scene, with the foreground and background being noticeably out of focus. Or, the depth of field may encompass the entire crime scene seen through the viewfinder.

Figs. 2.25 to 2.27 show three views of staggered evidence numbers. Fig. 2.25 shows a short depth of field with the focus set on the front number. Fig. 2.26 shifts this short depth of field, and the focus in now on the rear number. Fig. 2.27 shows a depth of field large enough to encompass all the numbers. Were these multiple items of evidence within a crime scene, it would be important to have them all be in focus at the same time. For most crime scene photography, maximizing the depth of field is a critical skill. Having the largest depth of field possible does not usually happen by accident. The photographer must know the camera variables that affect the depth of field and then purposefully select the setting of each variable so that it maximizes the depth of field.

Focusing to maximize the depth of field is one distinguishing feature of crime scene photographers that separates them from other photographers. Portrait photographers, for example, frequently want the background of their images to be out of focus to force the viewer of their images to concentrate on their models. Crime scene photographers, however, should usually strive to ensure everything in their images is in focus.

Why? For several reasons. First, if a substantial amount of the image is out of focus, it may not be a "fair and accurate representation of the scene." When crime scene photographers were at the crime scene, as they looked around the scene, each part of the scene was in focus. If a photograph of the crime scene does not also show the scene to be in focus, then it is not as the photographers viewed the scene. Second, a defense attorney may be able to successfully argue that possible exculpatory evidence was located in areas currently appearing to be out of focus. The attorney would remind the court that most photographers know how to minimize the depth of field to intentionally blur selected areas of a scene, suggesting the crime scene photographer had done so purposefully. Third, a defense attorney may be able to successfully argue that the photographer was too incompetent to create a properly focused image, and the image should be excluded as being substandard and unprofessional. These ideas and others will be discussed at length in chapter 12, "Legal Issues Related to Photographs and Digital Images" on the legal issues related to crime scene photography.



FIGURE 2.25
Wide aperture: focused on front.
GWU MFS Student M Simms.



FIGURE 2.26
Wide aperture: focused on rear.
GWU MFS Student M Simms.



FIGURE 2.27
Small aperture: entire range in focus.
GWU MFS Student M Simms.



FIGURE 2.28
Depth of field scale.

Many nonprofessional photographers compose their main subject in the viewfinder and then just rotate the focusing ring until their main subject comes into focus. You may now be saying, "Of course, what else would you do?"

Crime scene photographers should be able to optimize their focusing by use of other focusing techniques, which are known to provide better depth of field. The following techniques are mentioned here briefly because they fall under one of the Cardinal Rules this author believes are worth stressing. They will be elaborated on further in the chapters on Exposure (chapter: Crime Scene Photography) and Focusing (chapter: Focus, Depth of Field, and Lenses).

1. Use the **Reciprocal Exposure** that uses the smallest aperture. Multiple shutter speed and aperture combinations result in the **same** exposure level. The use of small apertures results in a larger depth of field range. For instance, the following exposure combinations are reciprocal exposures because they will produce images with the same exposure: f/22 and 1/60; f/16 and 1/125; f/11 and 1/250 and f/8 and 1/500. Although they all produce the exact same exposure, they differ in the resulting depth of field ranges. Of the four combinations, the f/22 and 1/60 will result in the longest depth of field range. If all four produce good exposures, why not select the one exposure combination that also maximizes the depth of field range?
2. **Hyperfocal focus** when infinity is in the background. **Hyperfocal Focusing** maximizes the depth of field range for large outdoor crime scenes. Hyperfocal focusing usually requires the use of a depth of field scale (see Fig. 2.28), along with the camera's distance scale. Hyperfocal focusing will be further explained in detail in chapter "Focus, Depth of Field, and Lenses".
3. **Zone focus** when infinity is not in the background. Or, if your lens does not have a depth of field scale, focus by the "rule of thirds." These two focusing techniques, which result in virtually the same depth of field range, maximize the depth of field for smaller scenes. Both **Zone Focusing** and focusing by the rule of thirds will be explained in detail in chapter "Focus, Depth of Field, and Lenses".
4. **Prefocus** the camera. This is usually done when setting up to take 1:1 images of small evidence, like fingerprints. Set the camera at its closest focusing position by rotating the focus ring on the lens to its shortest focusing distance. Many times, the close focusing of smaller types of evidence, like fingerprints, will require the use of a macro lens, as mentioned previously.

To prefocus the camera with a macro lens set to 1:1, move the camera, mounted on a tripod, toward the subject (a fingerprint on a wall, for instance) until the subject comes into focus. Set the tripod down at that position. If the fingerprint is on a horizontal surface, the camera is moved in and out until it is in focus by extending or retracting the tripod legs or the tripod's center stem. It would be possible to arbitrarily place the tripod too close to the evidence, in which case focus will never be achieved. Or, if the tripod were to be placed too far away from the evidence, it would be possible to eventually refocus on the evidence, but then the evidence would be smaller in the viewfinder than necessary. By prefocusing the macro lens, and then moving the camera toward the evidence until it is in focus, you ensure the evidence is as large as it can be in the viewfinder.

These focusing techniques frequently result in a depth of field range that encompasses the entire crime scene or area of interest. What if the depth of field is not adequate to ensure everything will be in focus? If the lens being used has a depth of field scale (see Fig. 2.28), very precise determinations of the depth of field range can be made and known to the photographer before the photograph is taken.

If the photographer knows part of the foreground or part of the background will be out of focus, what should be done? The answer should be clear. If you are responsible for not only what appears in your foreground and background but also for whether or not it is in focus, then the same solutions are available. If the foreground or background is distracting to the overall purpose of your image, recompose the scene until the distracting foreground or background is no longer in view. If it is known that the foreground or background will be out of focus, recompose the scene until the out of focus foreground or background is no longer in view.

Recomposing the scene may require raising or lowering the camera's view of the scene. It may require getting closer to the primary subject matter to compose the scene tighter, thereby cropping the scene in the viewfinder. The depth of field scale, and the other focusing techniques mentioned previously, will be explained in great detail in chapter "Focus, Depth of Field, and Lenses".

Cardinal Rule #3: Keep the Film Plane Parallel

In these times, when most law enforcement agencies have switched to digital imaging, it is fair to ask why this Cardinal Rule has not been reworded to something like, "Keep the Digital Sensor Parallel." When this author first learned crime scene photography, 36 years ago, the constant admonition was to "Keep the Film Plane Parallel" (Fig. 2.29). This idea can be expressed several other ways: keep the back of the camera parallel to the subject; keep the length of the lens perpendicular to the subject; keep the front lens element parallel to the subject; or keep the digital sensor parallel to the subject. These all mean the same thing! Many times, the best composition is to avoid diagonal views of the subject. While working on this third edition, this author has strived to replace references to "film" with the term "sensor." In this case, however, the decision was made to retain the original Cardinal Rule. It is the author's homage to our roots in film photography. As long as you understand the important concept, the exact phrasing is unimportant.

Which angle of view is best for the primary subject? Often, having the film plane parallel to the main subject is best. Fig. 2.37 provides an example of this, using the composition of a midrange photo to make the point. Here the "primary subject" includes both the pistol and a door frame as the fixed feature, with the intent to show the spacial relationship of the two also important. An imaginary line between the pistol and door frame is parallel to the back of the camera.

This is the first opportunity for this author to stress one very important point. Over the years, individual photographers will frequently develop a set of preferences when they take their photographs. This may be the result of their training, or it may come from experience, when multiple attempts to capture a particular type of subject have indicated which technique is usually most successful. This author is no different. This book is the result of years of taking photos at crime and accident scenes. This author does have a very definite preference for certain techniques. You may also have your own preferences, different from the author's. Just because the author's recommendations are provided in this text does not make them any better than the photographic techniques you may currently be employing. This author is constantly learning from other photographers. At no time should you think that this author believes the suggestions in this text are the only way to produce high-quality crime scene images. This author is constantly asking other photographers for their ideas, or for their "Tips, Tricks, and MacGyvers." However, the techniques in this book have worked for the author. Try them, or at least consider them. If you have a different way, or a better way, of getting the photographic job done, please send your ideas to the author. Your suggestions may become a new part of this author's bag of tricks. And, you may read about it in the next edition.

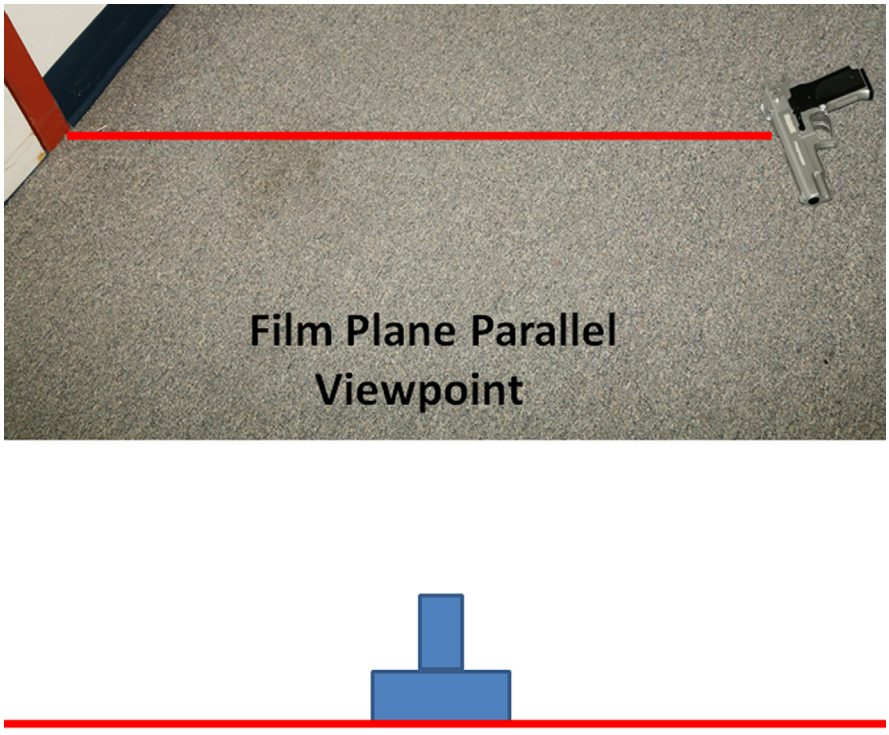


FIGURE 2.29
Film plane parallel.

OVERALL PHOTOGRAPHS

With overall photographs, building facades and walls are best photographed with the film plane parallel to those surfaces. Why? These three considerations are the reason.

1. Diagonal views have part of the wall closer to the camera and part of the wall farther from the camera. This makes part of the wall larger and part of it smaller. Often, it is not known during the early crime scene photography which areas are more important than others. Therefore, to the extent possible, it is best to have everything the same size, so there is not an emphasis on one part of the scene by having it larger than another part of the scene. Also, it would be unfortunate if several days after the crime scene photos were taken, it became known that the point of entry/exit was through a door or window at the far end of a wall photographed with a diagonal viewpoint. This would result in the point of entry/exit being very small and difficult to see.
2. Again, diagonal views have part of the scene closer to the camera and part of the scene farther from the camera. This creates a distance issue between foreground and background. Because it is best to have this entire expanse in focus, it is necessary to manage the depth of field to ensure both the foreground and background are in focus. As the distance between the foreground and the background becomes greater, it becomes more and more possible that the depth of field range may not cover the foreground-to-background distance. To eliminate this concern, compose the scene with the film plane parallel to the facade, wall, or area of primary interest. Having the film plane parallel to the scene will help ensure everything is in focus.
3. And, again, diagonal views have part of the scene closer to the camera and part of the scene farther from the camera. When electronic flash is being used to light the scene, the larger the scene, the more likely a single flash will be unable to illuminate the entire scene. If the flash is set to properly expose the rear of the scene, the foreground will be overexposed. If the flash is set to properly expose the foreground, the background will be underexposed. These differences of exposure are eliminated when the flash is equidistant to both the left and right side of the scene.

Let us see examples of this idea. Both images in Fig. 2.30 show two diagonal views of a building's front facade. A quick and careful look at both images show an obvious softening of the focus from the near side of the building to the far side of the building. And, the two images are needed because with just one of the images, seeing the far windows and doors becomes difficult because they are not only smaller, they are a bit out of focus.



FIGURE 2.30
(A) Diagonal view of a facade. (B) Diagonal view of a facade.
GWU MS Student D. Rio.

The alternative is to photograph the front facade with the film plane parallel, as is shown in the sequence of photos, Figs. 2.31 to Fig. 2.34. Doors and windows are easier to see and the focus does not suffer when the left and right sides of the four images are the same distance from the photographer, or they are composed with the film plane parallel.



FIGURE 2.31
Facade with film plane parallel.
GWU MS Student D. Rio.



FIGURE 2.32
Facade with film plane parallel.
GWU MS Student D. Rio.

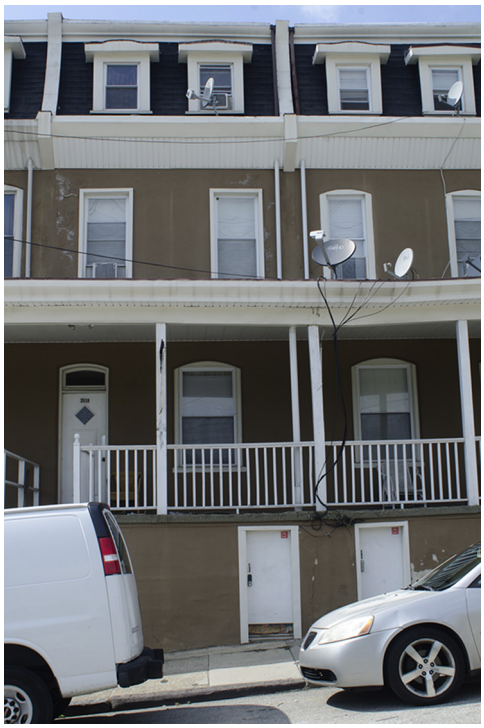


FIGURE 2.33
Facade with film plane parallel.
GWU MS Student D. Rio.



FIGURE 2.34
Facade with film plane parallel.
GWU MS Student D. Rio.

There are some well-known exceptions to the preceding rule:

1. When standing with the film plane parallel to a wall, the lens will be perpendicular to the wall. You will be directly facing the wall you are photographing. If the wall you are facing has a window or mirror, you might be able to see yourself or your flash, as a reflection. It is not recommended that you include yourself and your camera equipment in your own photographs. In this case, it is necessary to compose the scene from a slight diagonal viewpoint so that you will not be seen in your own photograph. Fig. 2.35 shows the worst possible situation: The entire wall is composed of windows. This image shows the reflection of the flash when the photograph was taken. The flash "hot spot" is in the center of the image. A very slight diagonal view is recommended to avoid this result. This view enables the photographer to compose himself or herself, and the flash, out of the image. The next two images in Fig. 2.36, show the entire wall, but the photographer and flash are no longer in view.
2. If you are using an electronic flash and the wall is highly reflective, maintaining the film plane parallel to the wall will usually result in a bright "hot spot" on the wall, especially if the flash is mounted on the camera's hot-shoe. Here again, a slight diagonal viewpoint to the wall will eliminate the flash's "hot spot." Or, with the camera remaining in the same position, put the flash on a remote flash cord, and hold the flash as far away from the camera as you can, at a slight diagonal to the wall. Or, use bounce flash, to be explained later.
3. Of course, buildings will sometimes be so close together that it is impossible to stand far enough away from the wall to maintain a perspective with the film plane parallel to the wall. When there is no alternative, diagonal viewpoints will be necessary.



FIGURE 2.35
Flash hot spot in view.
GWU MFS Student K. Mentore.

(A)



(B)



FIGURE 2.36
(A) Slight diagonal view eliminates flash hot spot. (B) Slight diagonal view eliminates flash hot spot.
GWU MFS Student K. Mentore.

MIDRANGE PHOTOGRAPHS

With midrange photos (also sometimes called intermediate photographs, establishing views or medium view photographs), try to arrange the subject and the fixed feature of the scene so they are both the same, or as close to the same, distance from you as is possible (Think of an **Isosceles Triangle,** as shown in Fig. 2.37. The photographer will be at one point of the triangle, and the evidence and the fixed feature of the scene will be at the end of the two equal length sides of the triangle.).

Another way to think of this is to have the film plane parallel to an imaginary line formed by connecting the evidence and the fixed feature of the scene, as previously shown in Fig. 2.29. Both Figs. 2.29 and 2.37 have the camera shown composing a midrange photo of the pistol and door frame. This viewpoint eliminates perspective distortion, where one item looks closer to another than it really is.

An easy way to visualize this idea is to consider a wagon wheel, with equal length spokes, see Fig. 2.38. When the wheel is viewed upright, from the side, all the spokes/diameters have an equal length. However, drop the wheel on the ground, see Fig. 2.39, and look at it from a perspective view. The circle turns into an ellipse, and the spokes appear to be different lengths, although you know they are all still the same length. This is dramatically shown by dropping three equal length lines, shown in different colors, over different spokes/diameters. Clearly, the wheel spokes/diameters appear to be different lengths. It is the perspective view that makes the different spokes/diameters appear to be different lengths. Since a midrange photograph is supposed to demonstrate the accurate distance between the evidence and a fixed fixture of the scene, the only accurate arrangement of the evidence and fixed feature is to compose them so they appear at the ends of the horizontal spoke/diameter, as in the blue line of Fig. 2.39. Avoid both diagonal and/or linear alignments of the evidence and fixed feature!

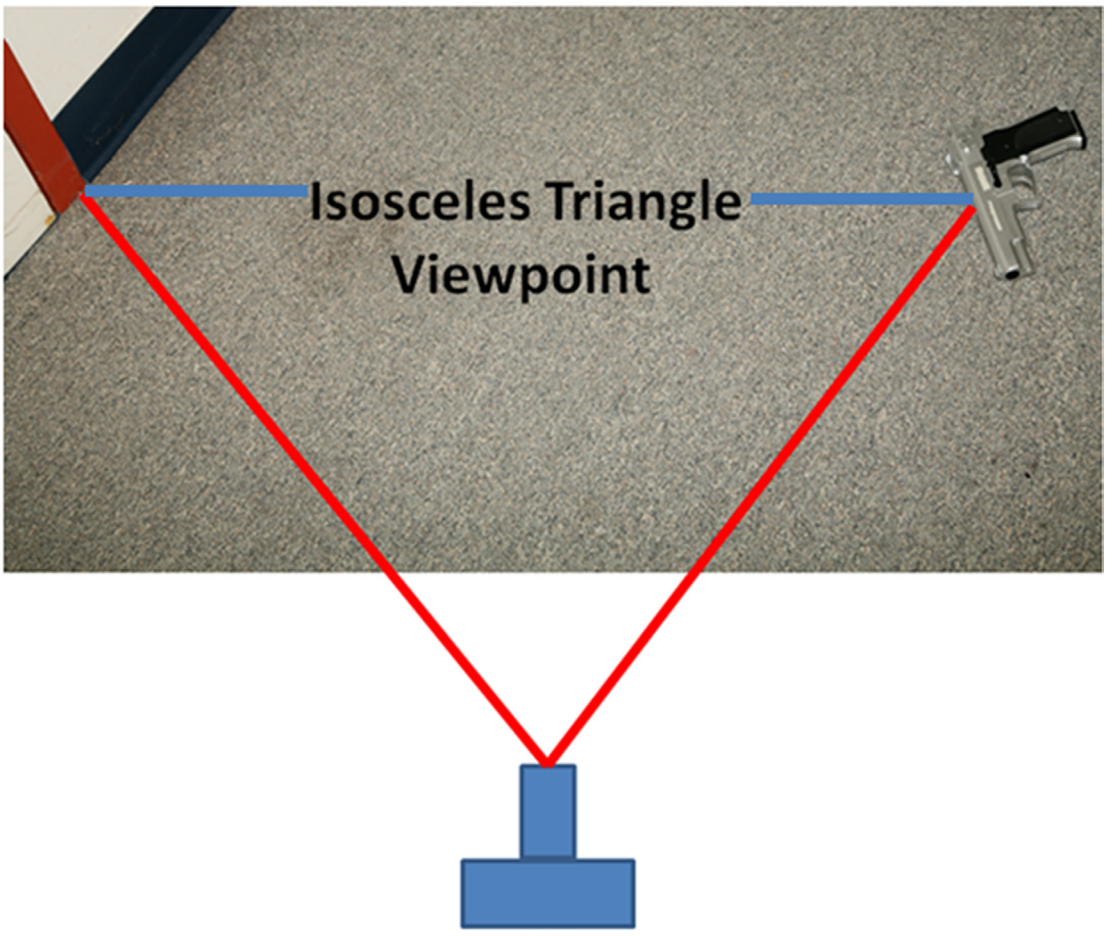


FIGURE 2.37
An isosceles triangle view used for a midrange composition.



FIGURE 2.38
A wagon wheel viewed from the side: all spokes equal lengths!

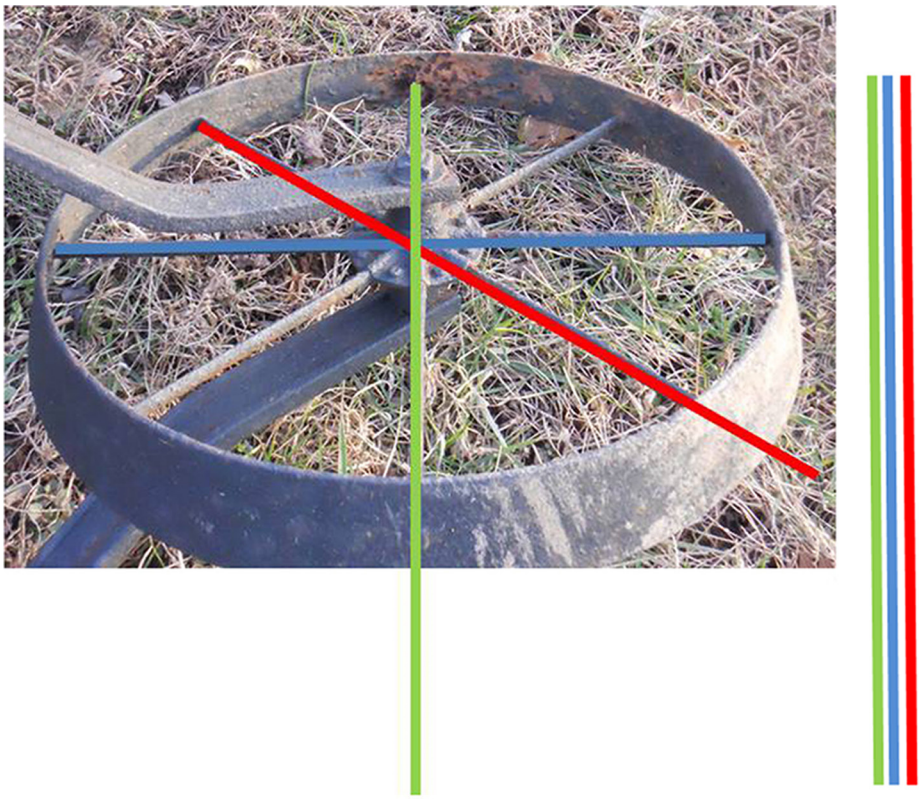


FIGURE 2.39
The wagon wheel laid down becomes an ellipse, with apparently different length spokes.

Fig. 2.40 shows three improper compositions, and Fig. 2.41 shows one proper viewpoint, for photographically capturing the distance relationship between a cartridge casing and a silver electric box. Fig. 2.40 shows the casing and electric box aligned from three *linear* points of view. A linear point of view aligns the photographer, one item of interest, and a second item of interest in a single line. Each of these three compositions shows a different perceived distance between the casing and the fixed feature of the scene. The photographer took these photos by standing at full height, kneeling, and then lying prone. These are examples of perspective distortion. *Linear* viewpoints should *always* be avoided when taking midrange photographs because of this perspective distortion effect. Each of the three photographs was taken with the camera at different heights. Are any of the three depicting an accurate distance between the evidence and the fixed feature? No. Raising the camera higher or lowering it changes the perceived distance relationship between the casing and the electric box. If it was the purpose of the photographer to show the viewer, and ultimately this will be a judge and a panel of jurors, the real distance relationship between the casing and the electric box, all three of these photos fail. The photograph in Fig. 2.41, where the film plane is parallel to an imaginary line between the casing and the electric box, does show the proper distance relationship between the two items of interest. There is no perceived distance distortion when viewed from this position.

However, there will be times when establishing this particular viewpoint, with the film plane parallel, may be impossible because of the layout of the scene and the number of other objects within the scene. Attempt to approximate this viewpoint, film plane parallel, however, as much as possible.

CLOSE-UP PHOTOGRAPHS

Having the film plane parallel to the evidence is also optimal with close-ups of the subject. Frequently, if the film plane is not parallel to the subject, the close-up cannot be used for comparison purposes.



FIGURE 2.40
Left: Linear alignment, while standing. Middle: Linear alignment, while kneeling. Right: Linear alignment, while prone.



FIGURE 2.41
Proper alignment: Film plane parallel.

One of the differences between overalls, midranges and close-ups is the presence of a scale in the close-up photographs. As will be discussed further in the next chapter, three of the four types of close-up photographs have scales in them. The presence of a scale will allow that photograph to be enlarged to life-size. A comparison between the photograph and the actual item of evidence seen in the photograph can be done if the evidence is eventually seized. To do this job, there are two aspects of the scale that must be remembered. One is that for the scale to facilitate an accurate enlargement of the evidence, it must have been placed "on the same plane" as the evidence. This will be explained further in the next chapter. Second, and related to the Cardinal Rule to keep the "Film Plane Parallel," the photograph of the evidence and the scale needs to have been taken with the camera positioned so the film plane, or the back of the camera, was parallel to the evidence. If an angled view of the evidence and scale is captured, the enlargement will not be able to be done unless the image can be rectified, or the viewpoint corrected as if it were originally taken from directly above the evidence. Sometimes this can be done, and sometimes it cannot. But, this extra step should not have been made necessary by an original improperly composed image.

How is such an angled view determined to have been taken? Simple! An angled view of a scale will show the scale distorted so it does not appear to be a rectangle.

Fig. 2.42 shows close-up photographs of an electrostatic dust print lift with incorrect and correct compositions. The scale in the Fig. 2.42A does not appear to be a rectangle, so it was taken with the camera diagonal to the dust print. The scale does look rectangular in the Fig. 2.42B, indicating the image was correctly composed. If the shoe of a suspect were recovered, only the Fig. 2.42B would be suitable for comparison purposes. The Fig. 2.42A would have to be geometrically corrected in a software program like Photoshop before it could be directly compared with the suspect's shoe.

The three Cardinal Rules will be referred to constantly throughout this text. Adhering to them will make your photography better than the average crime scene photographer's images. Remember them!

CARDINAL RULES OF CRIME SCENE PHOTOGRAPHY

1. Fill the frame.
2. Maximize depth of field.
3. Keep the film plane parallel.

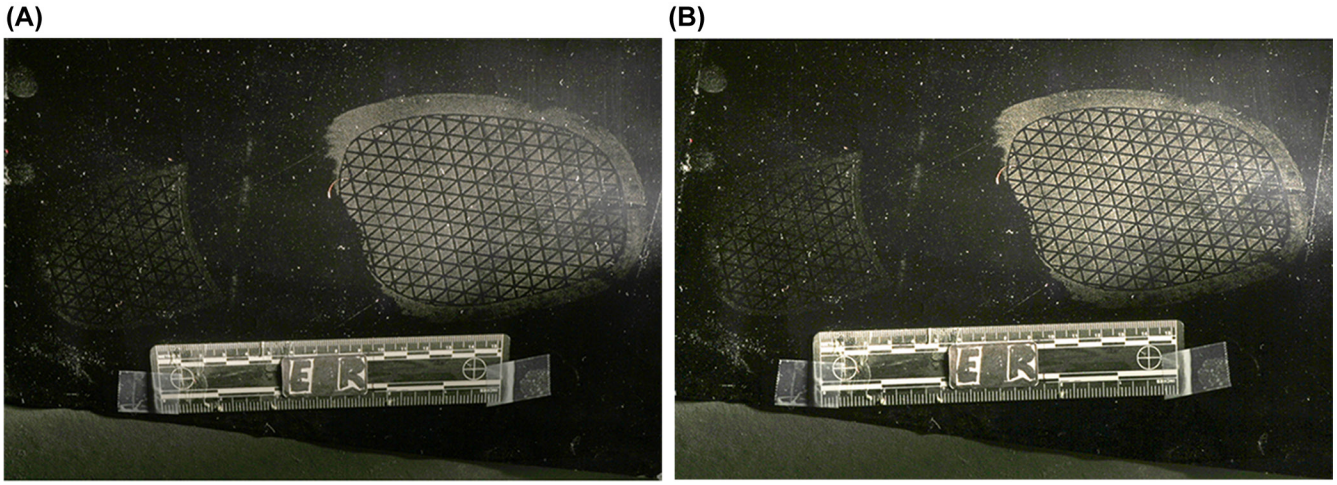


FIGURE 2.42
(A) A dust print lift taken from a diagonal viewpoint. (B) A dust print lift taken for a film plane parallel view.

Learning Objectives, Revisited

Many have considered photography to be grounded on both science and art. Photography is thought to be based, in part, on science because photography depends on the physics of optics and the mechanics of determining a proper exposure. Photography is thought to be based, in part, on art because photography that is considered to be "well done" is often a result of the creative expression of the photographer. Both are usually necessary to create a successful image. This chapter emphasized the need to develop a crime scene photographer's eye by beginning to consider the elements of composition.

This chapter stressed several elements of composition. Photographers must first consider their own viewpoint of the subject. The same object or area may be best viewed from one direction rather than from another direction. What considerations may affect this choice? One viewpoint may include too many distracting elements, which are easily eliminated from a different viewpoint. One viewpoint may include the photographer's shadow, which should always be avoided if possible. If it seems impossible to exclude a partial shadow from being seen from one viewpoint, then totally covering a small area in shadow should be considered.

Once the "primary subject" has been determined, additional elements in the foreground and background and to the left and to the right of the "primary subject" should be eliminated from the field of view to the extent possible. This can sometimes be accomplished best by framing the subject with the camera held either horizontally or vertically, depending on the shape and size of the subject.

Composition suggests the photographer makes choices to optimally frame the subject matter. The composition of each image should be as carefully considered as either exposure issues or focusing techniques.

DISCUSSION QUESTIONS

1. Briefly explain why photography can be considered to be both a scientific enterprise and an artistic expression of the photographer.
2. Can a properly **exposed** crime scene photograph still be unsuccessful? Why?
3. How can the photographer's viewpoint affect whether an image correctly depicts the spatial relationship between two objects?
4. How can both ambient and flash shadows be controlled?

EXERCISES

The following are composition exercises only. As such, issues of exposure, focus, depth of field, and flash techniques are not considered. You may use an SLR camera set to program exposure mode and set the camera to autofocus. Or, you may use a point-and-shoot camera. Composition is the only issue in these exercises.

Construct an exterior mock crime scene with several items of evidence included in it.

1. Take an exterior overall image that shows the crime scene in its relationship to the surrounding neighborhood. Attempt to locate a single easily recognizable feature of the surroundings and include this feature with the crime scene. This may be a particular business, a house, intersection street signs, or a natural feature of the scene.
2. Take one exterior overall photograph, encompassing the entire crime scene, while attempting to eliminate everything not within the crime scene.
3. Take a series of images, capturing two sides of any building. Some larger buildings will require overlapping images if a single image will not capture the entire façade.
4. Select one of the items of evidence and take a midrange photograph of it with a fixed feature of the scene.
5. Take one close-up of that item of evidence, filling the frame with it.

Compare your images with those in this chapter and with other images on the Companion Website (http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646) of images, referring particularly to the following image folders: close-ups, composition, exterior overalls, and midranges.

Further Reading

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CHAPTER 3

Crime Scene Photography

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Key Terms

"As found," "As Is," or "In Situ" photographs
Body Panorama
Close-Up Photographs
Exterior Overall Photographs
Interior Overall Photographs
Labeled Scale
Midrange Photographs
Natural Perspective
Overall Photographs
Photo Identifier
Photo Memo Sheet

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain why carefully documentation of each photograph is necessary;
2. Explain three techniques by which photographs can be documented;
3. Explain how overall photographs relate to the general crime scene area;
4. Explain how exterior overall photographs are to be taken;
5. Explain how interior overall photographs are to be taken;
6. Explain how midrange photographs are best taken;
7. Explain the four types of close-up photographs;
8. Explain additional types of photographic concerns related to documenting the wounds of suspects and victims;
9. Explain the complete photographic documentation of a homicide victim at the crime scene.

PHOTO DOCUMENTATION FORMS

A crime scene photograph can eventually be offered as an item of evidence in court. And, since all evidence needs to have a chain of custody established, this applies to photographs as well. How can the judge be assured that the photograph being offered in court as evidence actually

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is an image from the incident in question? Could it be a stock image used as an example of what things should look like, but was actually produced as part of a training exercise? Could it be a photo from another crime scene?

One way an image can be established as being a photograph from a particular crime scene is to have the photographer who took the image testify in court. Photographers can state that they took the photograph, what the subject matter of the image was supposed to be, where it was taken, and when it was taken. Photographers can also testify about the camera and flash variables used to capture the image and defend these choices if necessary.

However, it is not absolutely necessary to have the photographer who took the photograph introduce an individual image in court. Courts will sometimes allow anyone who was present at the crime scene and is familiar with the subject matter of the photograph to testify that an image is "a fair and accurate representation of the scene" as he or she saw it at the crime scene in question.

Because crime scene images are frequently critical to a case, they are frequently challenged. The final chapter "Legal Issues Related to Photographs and Digital Images" addresses the issues related to the legal admissibility of photographs and images from a crime scene. In this chapter, three standard methods used to document photographs at a crime scene will be discussed. They are included in this chapter not only because this is a chain of custody issue but also because if you can somehow have the images themselves be self-documenting, they will more easily be accepted in court as evidence.

The Photo Identifier

At every new crime scene, the photographer's first image should be of a **Photo Identifier**.

Fill the frame with the identifier when taking this photograph. Although variations of identifiers are used by different law enforcement agencies, some common elements exist in most of them. Fig. 3.1 shows two examples of photo identifiers. They can be on preprinted sheets that the photographer fills out, or they can be handwritten on blank paper as needed. It is the information that is important. The photo identifier enables every image to be associated back to a specific photographer and the specific crime scene in question.

The basic information that should be included on the photo identifier includes the following:

- The case number: The case number is preferred to the crime type because the crime type may change between the time of the initial call that reported the incident and the type of case that is going to court. Incident types may change for many reasons. The seriousness of the case may go up in severity. A case originally reported as "shots fired" may subsequently end up in court as a homicide prosecution. The seriousness of the case may be revised downward. The initial report of a "rape" may end up in court as a simple assault because of plea bargaining. However, the case number does not change.
- The date when the first image was taken. Many agencies also include the time the first image was captured. Of course, the first image should be the photo identifier.
- The address/location of the photographs. Most frequently this is a street address. Sometimes a name of the business is also included, for example, First Virginia Bank, 123 Bank St. If a particular room or suite number applies, add this also.
- The name of the photographer. Initials, badge numbers or employee identification numbers have also been used.
- Some agencies indicate the number of the digital flash cards which is currently being used: 1, 2, etc. One may require multiple flash cards to completely document a crime scene.

Should any of the information on the photo identifier change, begin a new photo identifier. For instance:

- if the date changes. Processing a crime scene may continue into the next day.
- if the location/address changes. The address of a bank robbery may be used on the first photo identifier. But, if a suspect ran into a nearby parking garage where a weapon was dropped, the address of that parking garage should be used on a new photo identifier to photograph the weapon. If the suspect drove a car from the garage and was involved in a crash where the vehicle was disabled, before capturing images of the vehicle and the evidence within it, a new photo identifier using the address of the crash site should be used. And, if the suspect ran two blocks before eventually being apprehended with a bag of money, that address should be used on a new photo identifier before taking photos of the suspect, money, and other evidence at that location. When a search warrant is served on a second suspect's residence, another photo identifier will have to be used. All share the same case number, but the locations differ. If any particular image is challenged in court, it should eventually be able to be linked to the photo identifier immediately preceding it on the flash card on which it is captured.
- if the photographer changes. Of course, if multiple photographers are documenting the same crime scene with their own cameras, they should all be using their own photo identifiers. However, it is ok for a second

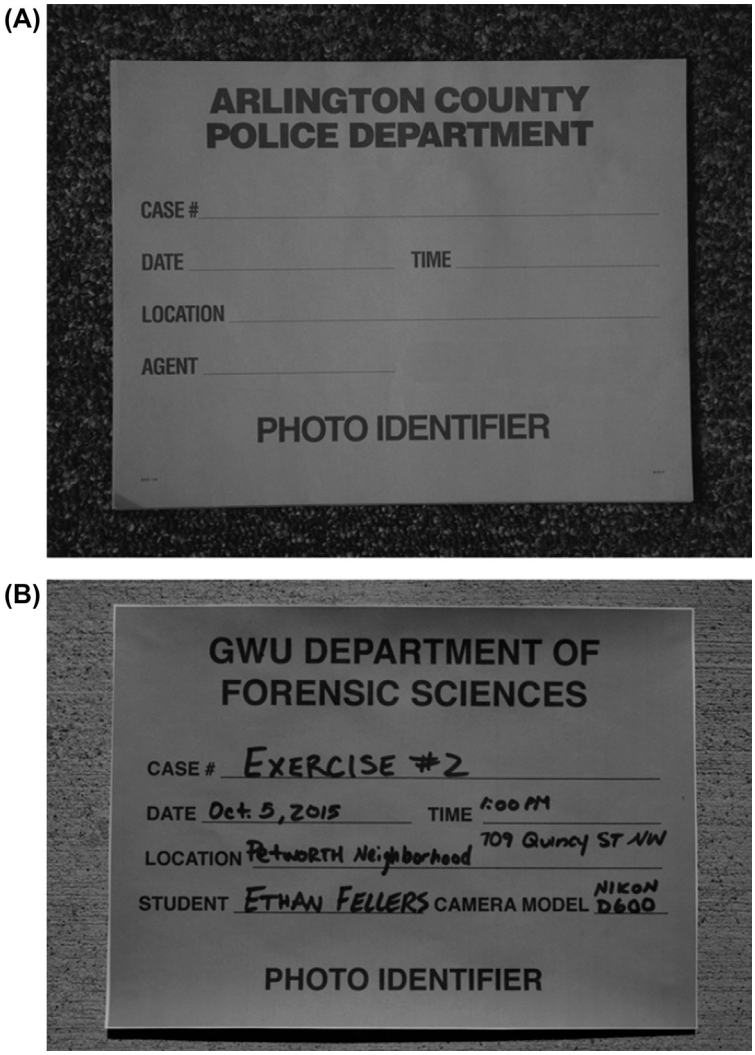


FIGURE 3.1
Photo identifier. (A) *Courtesy of the Arlington County Police Department, VA.* (B) *Courtesy of GWU MS student E. Fellers.*

photographer to use your camera to take one, or a few, photos if, for instance, it involves a photographic technique better understood by the second photographer. That second photographer should begin their first photo with a new Identifier, and when the original photographer resumes their photography, another Identifier is used to document who is currently using the camera.

A Rule of Thumb is associated with the photo identifier.

RULE OF THUMB 3.1

Anytime one of the variables on the photo identifier changes, a new photo identifier needs to be photographed.

Examine Fig. 3.1A, used at the agency this author retired from. When this author first began crime scene work in the late 1970s, the identifier was the same, except it was on white paper. Why the change? Many automatic film printers determined the correct exposure values to print the entire roll of film by the density of the first negative. Because we had used identifiers on white paper, we intentionally overexposed the identifier to keep it from looking underexposed as the camera meter was prone to do. Some exposure errors were generated by the use of the white paper as the first frame of every roll of film. We switched to gray identifiers, and our exposure errors were reduced.

Having changed completely to digital imaging now, the gray toned Identifier kept being used. They also can be used as 18% gray cards.

If one case does not require filling a memory card for a particular crime scene, it can be left in the camera; then, at the beginning of the next case, a new photo identifier is used to begin the series of photographs for that case. It is possible some agencies have standard operating procedures (SOPs) regarding this issue. Some may require just one case should be put onto any memory card before it is turned in for processing. If your agency's policy is to put only one incident on each roll of film, comply with your agency's policy.

The Photo Memo Sheet

Many law enforcement agencies require that every individual photograph be logged on a **Photo Memo Sheet**, which is a form to log all the specific data related to the camera, lens, flash, and specific variables used to capture each individual digital image. However, since digital images frequently retain all this same information in the metadata of every image's file, some agencies have discontinued this practice. However, I have downloaded some images onto a computer, and tried to find the metadata, and could not locate it. Somehow the metadata was lost. Because of this possibility, it might be a good precaution to continue using the photo memo sheet. Of course, the best recommendation is to follow your agency's SOPs.

Different agencies have variations of the sample photo memo sheet shown in Fig. 3.2. This form is actually a montage of photo memo forms from several different agencies. This form will also tell a photography instructor just how the student created each image they may be required to take during a training class. This form probably includes more information than a working law enforcement agency might expect from crime scene photographers at actual crime scenes, but if you like any of the ideas on this form, feel free to use them.

Case Number **Date/ Time** **Address/ Location** **Lens:** Indicate mm used, or Macro = M

Photographer **Roll #** **Camera** **Film ISO** **Light:** Available: **A;** Flashlight: **FL** M Flash: **M, M/2, M/4, M/16;** Auto: **P, B or R;** or **TTL**

(With Close-Up filters, indicate either M+1 through M+7 in the lens column.) (Indicate GuideNumber of Flash) _____

#	Lens	Light	SS	F-#	Description
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					

Notes:

FIGURE 3.2
Photo memo sheet.

Two reasons exist for documenting all data regarding the capture of each image.

First, when the case eventually goes to court, several months or years after the images were originally captured, a properly filled out photo memo sheet can be used to "refresh the memory" of the photographer about the specifics of each image.

Second, if any particular image did not come out quite as expected, the details in the photo memo sheet can possibly be used to figure out what went wrong and can be used to ensure images taken under similar circumstances in the future are improved. The photo memo sheet is a means by which past mistakes can be corrected. If one particular photograph is not as successful as it might have been, knowing how it was taken may suggest why the photograph looks the way it does. It might then suggest a different technique to make the next attempt in similar circumstances more likely to be successful. With good notes, you can learn by your previous mistakes.

The best time to log a photograph on the photo memo sheet is immediately after taking the photograph. Trust nothing to memory. Immediately log each photograph as it is taken. If having an assistant act as your scribe is a possibility, take advantage of this luxury. Otherwise, this job falls on the shoulders of the individual photographer. It may take a bit of juggling to manage a camera, a flash on a remote flash cord, and a clipboard with the photo memo sheet on it, but you will soon get used to holding the clipboard with your knees while taking an individual photograph.

Invariably, the "description" on line 1 of the photo memo sheet should be "photo identifier."

The Labeled Scale

Each item of evidence should include several **Close-Up Photographs**. It is a standard practice to include a **Labeled Scale** in at least one of the close-up photographs. Not just a scale; a labeled scale. Why not have the scale indicate more than just dimensions? Remember, to the extent you can have the image "tell" the judge, jury, and both attorneys what they want to know about an image, the easier it will be to get the image admitted into court as evidence. Through the use of a scale with the proper labeling information on it, the image can approach the goal of having the image be "self-documenting."

A labeled scale can be a preprinted form, or it can be as simple as a 6″ ruler with a removable label on it. Either way, the same information should be included on the scale.

Notice that both of the labeled scales in Fig. 3.3 are predominantly gray. Scales come in a variety of colors: black, white, gray, fluorescent, and transparent. It is normally recommended you choose a scale so that it is roughly the same reflectance as the item of evidence it is being used with. To the extent possible, it is a good idea to have the scale reflect the same quantity of light; it would be counterproductive to have the light reflected from the scale alter the exposure of the evidence it is being used with. Since a light meter or flash sensor is usually being used to determine the exposure of some images, having the scale be close in reflectivity to the evidence is important. Alternatively, using a gray scale usually will not alter the exposure value required for any item of evidence.

As will be mentioned in the subsequent chapters, "Basic Exposure and Electronic Flash," it is recommended to use a black scale with the black Mylar film of a dust print lifter and to use a white scale with indented writing on white paper. You too may find it useful to keep differently colored scales for different types of evidence.

Many agencies assign an evidence number to the evidence as it is chronologically encountered. As each item of evidence is collected, it is assigned a number. This number should be indicated on the labeled scale when the close-up is taken. An effective way to accomplish this is to use four slash marks and a diagonal slash for each five numbers. Having the numbers be cumulative, rather than having to change or erase each number each time, keeps the labeled scale "cleaner." By doing this, you do not need to change the label as new items of evidence are photographed. It is also not necessary to scratch out the preceding number to add a new number. For example, evidence item 5 would be indicated like this (Fig. 3.3B).

If someone, or his or her injuries, is being photographed, indicate the person's name on the labeled scale. This information should be on a separate label so it can be removed after the photographs of that person have been taken.

The labeled scale must **not** just be put down alongside of the evidence! It is critical to understand that the labeled scale needs to be placed on the **same plane** as the evidence. This Rule of Thumb is critical to good crime scene photography.

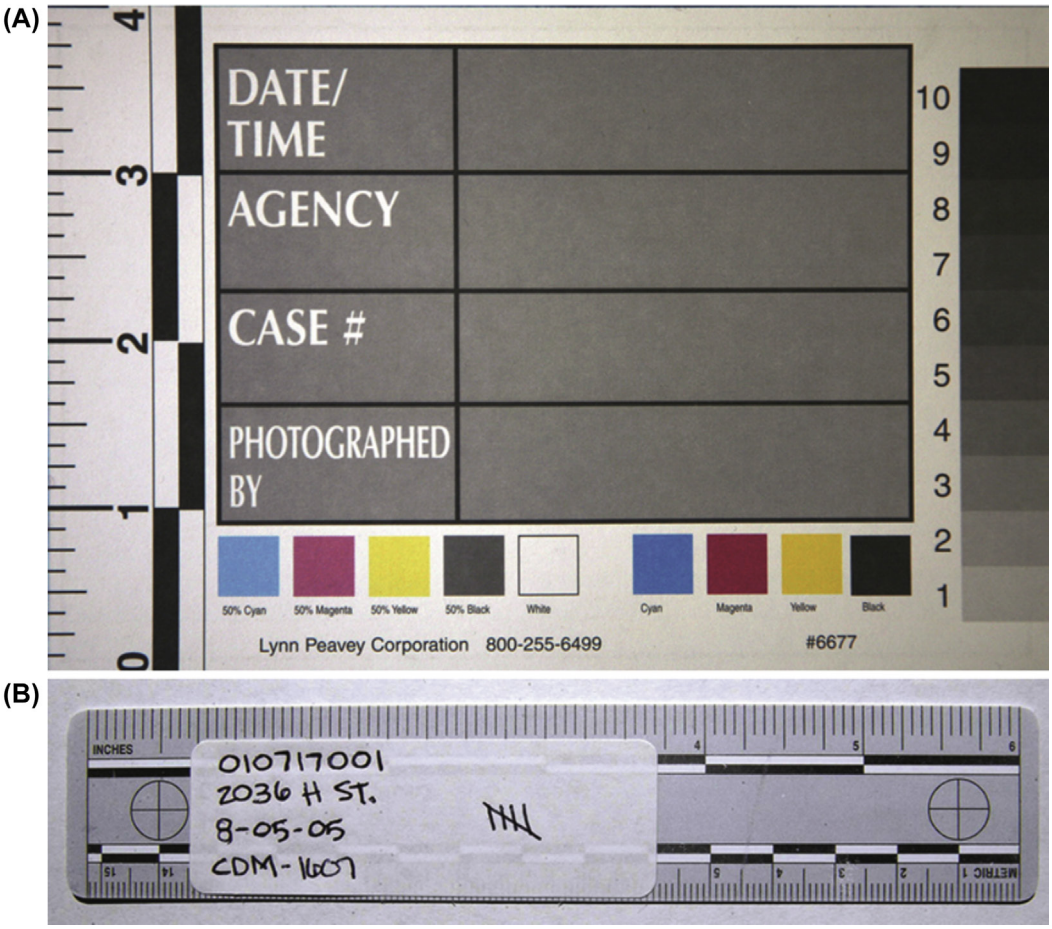


FIGURE 3.3
(A) A commercially available labeled scale. (B) A labeled scale.

RULE OF THUMB 3.2

Whenever scales are used, they should be positioned on the **same plane** as the evidence.

If a handgun is being photographed, and you focus on the top of the gun, the labeled scale has to be at the same height as the top of the gun. A variety of props can be used to raise the labeled scale up to the necessary height. Lens caps, coins, and pocket notebooks have all been used frequently. When all else fails, and it seems impossible to find props of just the right height, folded paper can be made into small A-frames of the desired height (see Fig. 3.4). Forgot why the scale should be on the same plane as the evidence? There are two reasons:

1. To have the scale in the composition enable the size of the evidence to be determined, it is necessary to have the scale be **on the same plane** as the evidence. If the top of the evidence is the point of focus, the scale must be at that same height.
2. With close-up photographs, depth of field is severely reduced. It would be possible to have the top of a weapon be in focus, but the surrounding surface, on which the scale is positioned, may be slightly out of focus.

The images in Figs. 3.4 and 3.5 show two items of evidence and the props used to get the labeled scale to the height of the evidence.

Another consideration is to consciously avoid having the props appear in your close-up photographs. I do not believe an image would be thrown out of court just because a prop holding up a labeled scale can be seen in the image. However, not having the prop shown exhibits the care and pride a photographer can display with their compositions. With just a little practice, this habit becomes second nature to the experienced crime scene photographer.

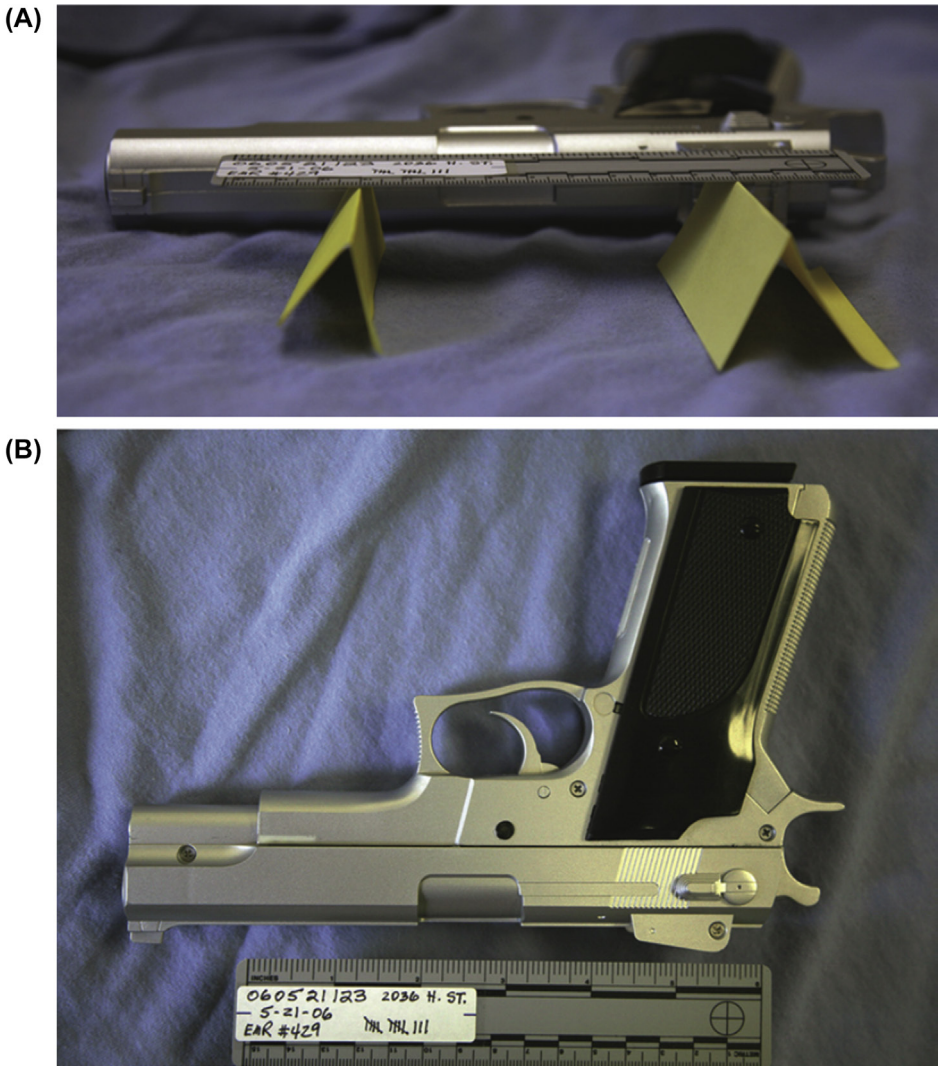


FIGURE 3.4
(A) Labeled scale on folded paper. (B) Do not let props be seen.

If the evidence is a shoe print in dirt, where the pattern of the shoe print is 1″ lower than the dirt, the labeled scale must be placed into a depression you have dug that places the labeled scale 1″ lower than the surrounding dirt. This ensures that the photograph of the evidence can eventually be enlarged to life size, so a shoe print examiner can compare the actual item of evidence, seized from a suspect, and the photograph.

It may be beneficial to the reader to "prove" that scales on different planes will vary in their ability to be focused on properly. Crime scene photographers have frequently just placed a scale alongside an item of evidence without much care about the scale being on the same plane as the height or depth of the evidence. When this "error" is pointed out, the reply is sometimes that this theory may be appropriate for a lecture in a classroom situation, but out in the "real world" such things are not really important. It is hoped that Fig. 3.6 convinces you which position is correct. In Fig. 3.6, two scales are placed adjacent to each other, but at four different heights.

On the top, the two scales are the same height. Each inch is obviously the same length and they are both in focus. A stack of nickels was used as a prop for both scales. On the lower left, the top scale of the pair was lowered by just one nickel, while the focus was set for the bottom scale. The fine dots making up the background of the top scale should appear to begin to blur. When the top scales in the next two pairs of scales have been lowered by 1/4″ and then 1/2″ the blur becomes more and more obvious. And, the length of each inch changes also. Always, the scale which is closest to the camera will appear to be the longest. That is, only half of the problem with scales not being on the same plane as the evidence.

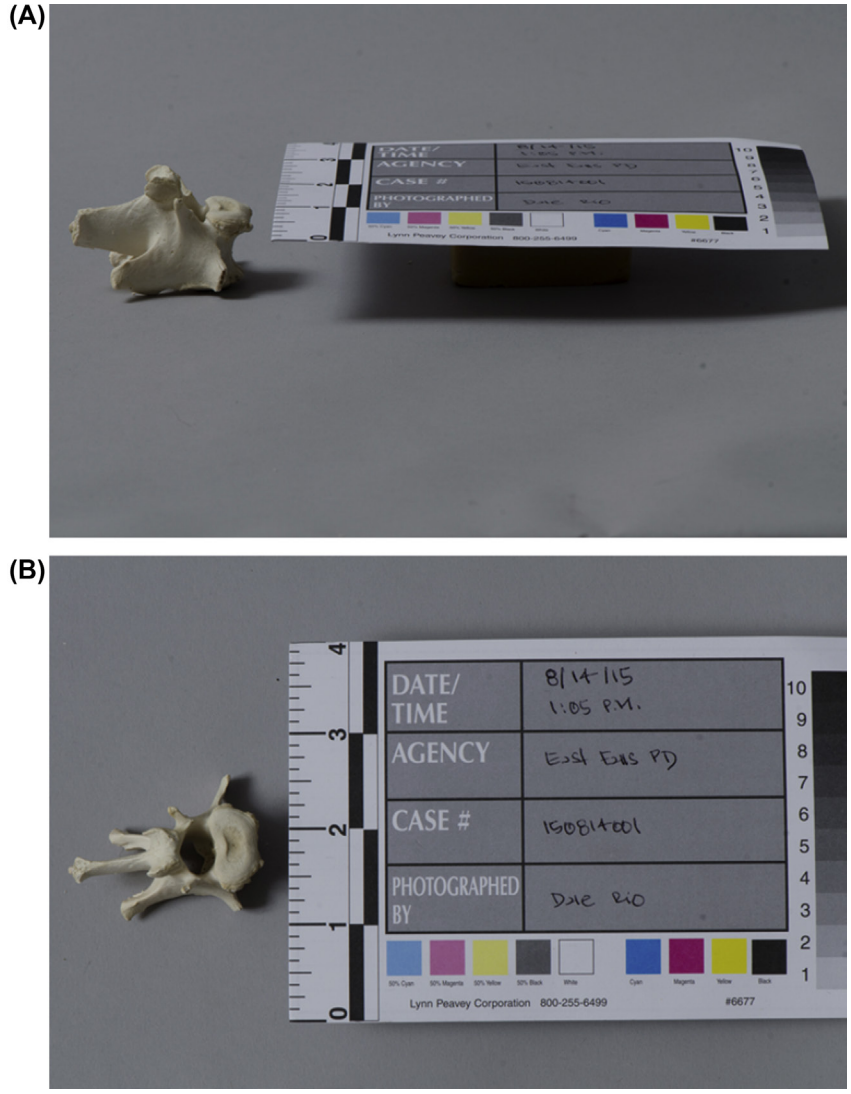


FIGURE 3.5
(A) Labeled scale on prop. (B) Do not let props be seen.
Courtesy of GWU MS student, D. Rio.

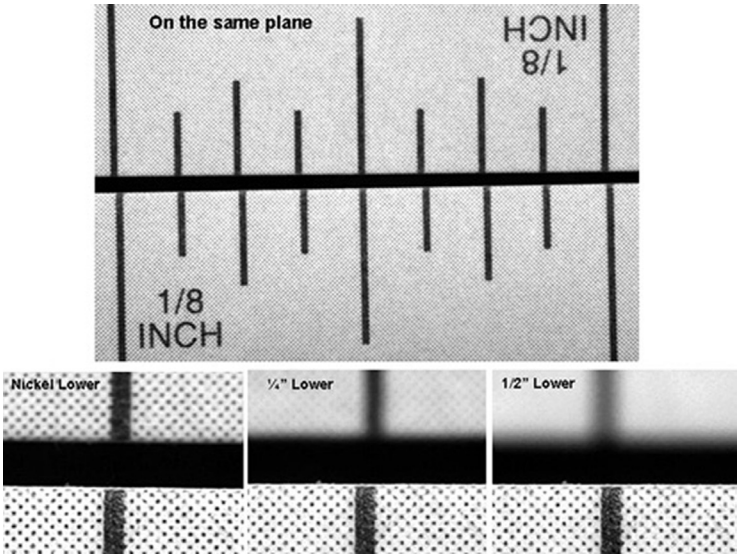


FIGURE 3.6
Scales on different levels: I.

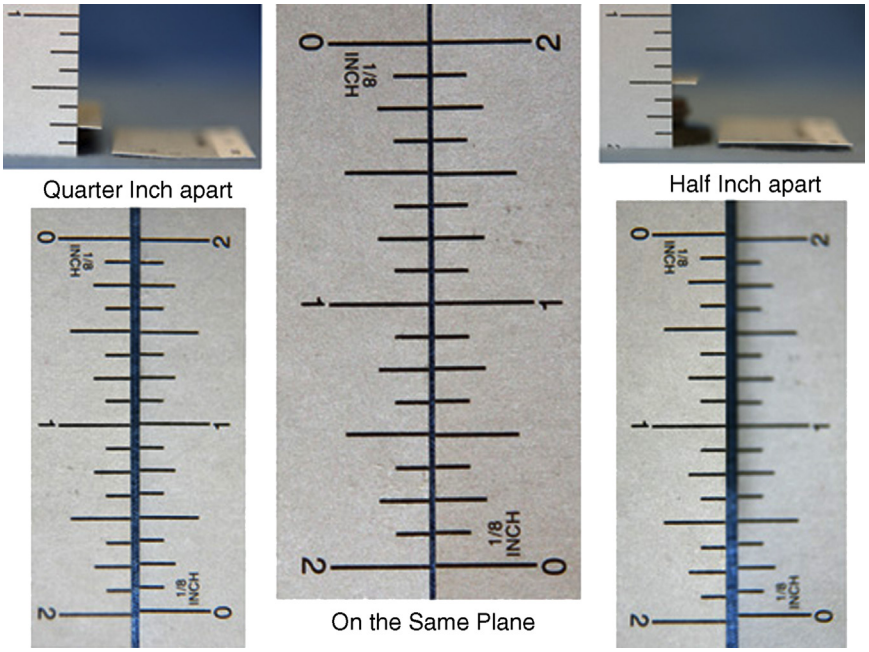


FIGURE 3.7
Scales on different levels: II.

If the scale is not on the **same plane** as the evidence, it is actually a different relative size, and the scale cannot be used to enlarge the evidence to "life size." If the scale is lower than the plane of the evidence that is focused on, the scale will be smaller than it really is. This would be the case if a gun were being photographed, with the scale laid on the floor next to the gun. If the focus is set for the top surface of the gun, the gun will be in focus, but the scale will be too small to properly enlarge the gun to life size.

If the scale is higher than the evidence, it will be relatively larger than the evidence. This would be the situation if a shoe print in dirt was being photographed, and a scale was laid on the top surface of the dirt alongside the impression. If the bottom of the shoe print is the point of focus, the scale will be relatively larger than it should be, meaning when the image is enlarged to "life size," in this case the size of the improperly placed scale, then the shoe print will be smaller than it should be, indicating a shoe of a smaller size. When the class characteristics do not match, in this case shoe size, examiners usually do not go to the next step of comparing individual details.

It is hoped that Fig. 3.7 will convince you of the necessity of having the scale on the same plane as the evidence. In the center of the image, two scales were laid alongside of each other, and each 1″ length matches up. The left two images show the two scales at different distances from the camera. Both of the left scales are 1/4″ higher than the right scale. Focus is on the left scale. The right scale is not only a bit out of focus but also "shorter." If the purpose for putting the scale into the composition was to enable the image to be blown up to life size, because the scale is the wrong size, this cannot be done.

The two right images in Fig. 3.7 also show the two scales at different distances from the camera. However, now both of the right scales are 1/2″ lower than the left scale, which is the scale being focused on. The right scale is not only out of focus but also "shorter." Again, if the purpose for putting the scale into the composition was to enable the image to be blown up to life size, because the scale is the wrong size, this cannot be done.

If the evidence is below grade, on the same plane as the substrate or positioned on top of the substrate, the crime scene photographer has to make the effort to lower or raise the scale to the same plane of the evidence being focused on.

"AS FOUND," "AS IS," OR "IN SITU" PHOTOGRAPHS

The first photographs at any crime scene should show both the layout and the evidence within the scene "**As Found**" before any alterations to the scene. Nothing should have been added to the crime scene; and nothing should have been taken away from the scene when the scene is first photographed. Another description of this is sometimes expressed as photographing the item of evidence "**In Situ**" (Latin for "in place"): in the situation it was originally found before any movement.

However, there are many times, and very good reasons, for some crime scenes to be altered before the designated crime scene photographer begins their work. For example, at a bank robbery, a suspect may be fleeing the bank when they drop some of the money. Whether the money is in a bag clearly designated as bank property or if it is just loose

bundles of newly minted bills, this money is not likely to remain laying in plain view for long. This is clearly something which needs to be collected by the first available officer "for safe keeping" as soon as possible. The same would apply to a weapon or a package clearly appearing to be drugs. If it has innate value, or if it represents a possible threat to the safety of the community, it should be collected immediately.

These things occur at many crime scenes. This is the issue: once the crime scene photographer does arrive at the scene, and just before they can take their first photo, should the seizing officer of one of these items be allowed to replace the evidence into the scene where they think it was when they seized it? The answer is, "No." They were perfectly correct to have seized it in the first place, and they just need to write up their reasoning in their report, but they should not be allowed to replace it in the crime scene.

The crime scene photographer will then proceed to photograph the scene as it was when they first arrived.

Now, here is a great "what if" to consider if you are so disposed. What if the officer picking up a bundle of Benjamins had the presence of mind to lay down a quarter beneath the bundle of bills just before he raised it? Very similar to what a golfer does on a putting green when his ball is closer to the pin than others. I think many would allow the crime scene photographer to photograph the crime scene with the quarter in it. I may be wrong, but this scenario has been knocking around in the back of mind for decades. I have yet to see case law on this point. Have you?

EXTERIOR OVERALL PHOTOGRAPHS—CRIME SCENE

Eventually, individual items of evidence will be photographed. For the importance of any individual item of evidence to make sense to the viewer, it will be necessary for that item of evidence to be related to the crime scene. The crime scene itself, in turn, will need to be related to the general surroundings around the crime scene. In this way, the complete story of the crime in question is documented. Every item of evidence needs to be linked to the crime scene. The crime scene itself must be linked to the general surroundings. The **Overall Photographs** do this job.

Natural Perspective

For the most part, overall photographs are taken from a **Natural Perspective**, which is a viewpoint of the scene that has the photographer standing at their full height. To the extent possible, try to avoid taking a picture when you are not standing at your full height. Of course, there are many times when this suggestion cannot be followed. If a bloody knifes us under the bed, it is your job to photograph it "as found." Then you must get very low in order to photograph it beneath the bed.

If a baggie of drugs is located on top of an armoire, then to photograph it "as found," you will have to find something to stand on just to see and compose it.

Nevertheless, a viewer of overall photographs should usually be able to presume the photographer was standing at their normal height when most of the photographs were taken.

Another exception to this rule is that at times it may be necessary to take aerial views of the crime scene to show the relationship of parts of the scene to the general neighborhood. Aerial photography, whether taken from a balcony, a rooftop, a cherry picker utility truck, a fire department's ladder truck, from drones or aircraft will be discussed separately, in the chapter "Special Photographic Situations."

Usually, however, overalls are not taken with the photographer kneeling or standing on a support to get higher. If this is done, notes should be kept to document this fact. Notes like this can go into the photo memo form. Unless the photographer specifically mentions this was done, the viewer of the image can presume the photograph was taken from a natural perspective. There will be times that a particular point of view is being documented, and sight obstructions may need to be included from the viewpoint of the photographer. A witness at a certain location may report having seen something from his or her original position. Photographs will then be taken from this witness' viewpoint. A driver of one of the cars involved in an accident may report not seeing the other vehicle because of a sight obstruction. In this case, it will be necessary to get the camera at the height of the driver's eyes to document obstructions from that perspective. However, these are the recognized exceptions to the general rule that overall photographs are normally taken from a natural perspective.

Exterior Overalls Photographs—Crime Scene

The crime scene photographer will want to create a complete story of the crime with the photographs that are taken. Most of the time, the judge and jury do not return to the scene of the crime. Adequate photographs can do this job for them. **Exterior Overall Photographs** relate the crime scene to the general surrounding area.



FIGURE 3.8
Street signs: emphasis on Georgia Av.
Courtesy of GWU MS student, L. Pachucki.

If the crime was committed indoors, overall photographs also show external views of the building in which the crime occurred. It will be the job of the crime scene photographer to walk the viewer of the photographs into the crime scene from its outer perimeter.

When possible, the crime scene photographer should frequently begin at the intersection closest to the crime scene. This may not be possible in some rural areas. But the idea is a good one to acclimate any interested parties of the crime to the general surrounding area.

When photographing street signs, do so in a way that indicates to the viewer which of the two street names is the one on which the crime occurred. Without this consideration, it would be possible to photograph the signs giving equal emphasis to both streets, which can leave the viewer confused about which is more important. When composing this shot, make the street the crime occurred on more predominant in the photograph. The images in Fig. 3.8 show this difference in emphasis. Both street names are visible in both photographs, but the photographer intentionally directed the viewer of each image to one of the streets by making one of them more prominent.

Many times, this kind of shot will have a large amount of sky as the background, which will tend to cause an underexposure. If this is the case, it may be best to take an exposure reading off a grassy area or well-traveled asphalt in the area to avoid exposure errors. If no green grass or well-traveled asphalt is nearby to take a meter reading on, then open up the aperture 1 to 1½ stops to prevent the underexposure the sky is likely to cause if the meter is relied on totally. At night, hitting the highly reflective sign with an electronic flash may wash out the sign entirely. Care must be taken that the flash does not strike the sign directly. Position the flash off-camera so the most extreme angle is used. Or reduce the flash intensity drastically to avoid reflection washout.

If a street sign is not handy, some other well-known point of reference can be used to orient the viewer of the photographs to the general area of the crime scene. This can be a well-known building, a natural feature of the area, or anything else the photographer believes can be used as a point of reference for the crime scene neighborhood.

In Fig. 3.9, on the left, the photographer attempted to relate a crime scene associated with the park bench on the left with the small white stone wall across the street with the cross carved into it. This would indicate the proximity of the scene to the American Red Cross building. The idea was good. The execution failed. Unfortunately, this composition includes too many irrelevant details, including an extended view of the background, and a passer-by sitting on another bench. Decide what is necessary for the shot, and then exclude what is irrelevant. Fig. 3.14, on the right, is the shot that should have been taken.



FIGURE 3.9
Left: an attempt to relate a park bench to a Red Cross sign. Right: this composition succeeds better.



FIGURE 3.10
(A) From intersection toward the crime scene. (B) Mid-block to the crime scene.
Courtesy of GWU MS student, D. Rio.

Once the street sign, or point of reference, has been photographed, take a photograph from the street sign or neighborhood feature, toward the crime scene.

Fig. 3.10 shows a view toward the crime scene from the intersection indicated in the photograph of the street signs. Moving from the intersection toward the crime scene, the crime scene photographer should take one or more additional images. Like Fig. 3.11, these additional images will give the viewers a good feel for the crime scene neighborhood. All these images should be taken with a 50 mm focal length on a digital camera with a full-sized digital sensor, or a 35 mm focal length on a digital camera with a smaller digital sensor. These last two ideas will be further explained in the chapter "Focus, Depth of Field, and Lenses." The use of a wide-angle lens or a telephoto lens can often elongate or compress the scene, respectively, and should normally be avoided when trying to accurately compose overall images of a neighborhood.

It should be said here that both wide-angle lenses and telephoto lens can frequently be used for overall photos, if you carefully use them for their strengths, while avoiding their weaknesses.



FIGURE 3.11
Front facade of a single family home.
Courtesy of GWU MS student, D. Rio.

The strength of the wide-angle lens is its ability to capture a wider view of the scene. Its weakness is its tendency to elongate the scene. This weakness can be eliminated as long as the photographer consciously crops out the elongated foreground in the field of view simply by raising the camera so the foreground is less pronounced, or entirely eliminated, in the composed image. This will mean there is more background or more sky in the field of view. So be it. As long as the elongated foreground is removed from the composition, the strength of the wide-angle lens makes it a very effective tool when capturing overall photographs.



FIGURE 3.12
360 degree of a single family home.

The strength of the telephoto lens is its ability to magnify distant details. Its weakness is its tendency to show the depth of the scene to be more compacted, or shorter, that it really was. This weakness can be eliminated as long as the photographer consciously crops out the compacted foreground in the field of view by raising the camera so the foreground is less pronounced, or entirely eliminated, in the composed image. When using a telephoto lens, attempt to just have the distant object in the field of view. Then, the telephoto lens is used for its positive attributes, and its negative attributes may not affect the image at all.

Once at the crime scene building, the entire exterior should be photographed. The purpose is to show all the possible ways the suspects could have entered or left the building. Even when it is believed that information is already known, it is a good practice to photograph the entire façade because new information may be developed during the course of the investigation that contradicts the original hypothesis.

Fig. 3.12 shows a simple residence photographed from all sides. In this series, a 33 mm lens was used with a digital camera featuring an APS-C sized digital sensor, which is smaller than a film negative or a digital camera with a full sized digital sensor. Again, more information explaining how the size of the digital sensor affects the relative focal length of a lens will be explained in the chapter "Focus, Depth of Field, and Lenses." Preference was given to views of each side with the film plane parallel to the walls of the building whenever possible. When obstructions require it, angled views were used. If one or more sides of the building are particularly long, a wide-angle lens can be used to minimize the number of overlapping photographs required to capture that façade. If a wide-angle lens is used, however, particular care should be taken to eliminate anything besides the building walls. If foreground parking lots or lawn details are included in a wide-angle lens composition, they will be elongated and therefore incorrectly depict the building's surrounding grounds. In this case, the composition of the building should ensure the bottom of the viewfinder ends with the bottom of the wall being photographed.

In Fig. 3.13, this advice was ignored, and the distance between the photographer and the building appears to get longer and longer. The top image was taken with a 50 mm lens, a "normal" lens, and the true distance between the photographer and the building. This is how anyone standing near the photographer would have seen the building with their own eyes. While standing in the same spot, the photographer took the middle image with a 35 mm lens, a short wide-angle lens. One should notice three changes compared to the top image: (1) the building looks further away than it really is, (2) we see more of the building, from left to right, which is exactly what a wide-angle lens is supposed to do, (3) the other side of the coin when the building looks further away is that the foreground appears to be elongated. There appears to be a greater distance between the photographer and the building. Then, while the photographer stood in the same spot, the lower image was taken with a 24 mm lens, a wide-angle lens with a wider field of view. There appears to be an even greater distance between the photographer and the building. The distance between the front sidewalk and the front of the building may become an issue being contested in court. In this case, only the image taken with a 50 mm lens should be allowed in court, because other images do not depict a fair and accurate distance between the front sidewalk and the building. Again, wide-angle lenses can be used to photograph the building as long as the image is composed so that the bottom of the building is at the bottom of the composition.

Fig. 3.14 shows the proper composition of another large building with lenses of different focal lengths. In these three images, again taken top to bottom with a 50 mm, a 35 mm, and a 24 mm lens, the wider angle of the lens just incorporates more of the building in the field of view, without deceiving the viewer about the size of the lawn in front of the building.

When taking exterior overalls, include a photograph of the building address or the building name. For instance, if the First Virginia Bank at 123 Bank Street is robbed, it would be appropriate to get a photograph of each designation; even better if they could both be composed in the same image.

If it is possible to photograph the exterior of a building with the film plane parallel to the walls of the building, this is preferred. At times, this will be impossible because the surrounding buildings may make it difficult to get in a position where the camera can be positioned with the film plane parallel to the walls.

Fig. 3.15 shows views of the same building. The top two images show the building photographed from diagonal viewpoints. The bottom four images are overlapping views of the building. If having a diagonal view of a wall of a building and having the film plane parallel to the wall are both possible, compose the building with the film plane parallel to the wall.

Five reasons exist why the compositions with the film plane parallel to a wall are preferred over diagonal viewpoints:

- In diagonal viewpoints, the near side of the building appears larger than the far side of the building. It is natural to believe the photographer composed the images for specific reasons and that larger parts of the scene are larger because the photographer wanted to emphasize one part over another part. If the film plane is parallel to the façade, the same emphasis is on the left and right sides of the building. Both sides can be seen equally well. Neither side is diminished in importance by making one side smaller.
- When one side of the building is closer to the camera, and the other side of the building is farther away, a depth of field problem is created. The photographer will want to ensure the entire façade is in focus, but it is possible that this may not be able to be done. With the film plane parallel to the façade, it is easy to ensure the left and right sides of the building are in focus at the same time.
- When the lighting is dim, electronic flash will have to be used. Flash cannot light areas near the camera and areas farther from the camera at the same time equally well. However, if the façade is composed so that both sides are the same distance from the camera, it will be easy to ensure equal lighting has been achieved.
- One of the purposes of these exterior overall photographs is to show all the possible means of ingress and egress. Having the film plane parallel to the façade does this job better. Doors and windows are easier to see when they are larger, the result of having the film plane parallel to the façade.
- If evidence is outside a building, this evidence will have to be related back to a fixed feature of the building with **Midrange Photographs** and measurements. All the fixed features of a building are better seen when the façade is photographed with the film plane parallel to the walls of the building.



FIGURE 3.13
Building: 50, 35 and 24 mm lenses.



FIGURE 3.14
Building: 50, 35 and 24 mm lenses.



FIGURE 3.15
Large building.
Courtesy of GWU MS student, D. Rio.

Another aspect of exterior overall photographs is to show the immediate area surrounding the crime scene. This can be done in several different ways. Views toward the crime scene building can be taken from various directions:

- Views toward the home or crime scene from both directions of the street.
- Views toward the home, or crime scene from both directions of a rear alley or a street behind the residence.
- Views from the residence outward down the street in both directions.
- Views from the residence showing other possible ingress and egress routes.
- Vehicles parked nearby. A suspect may have parked nearby but was unable to get to his or her vehicle for a number of reasons, and left it behind, intending to return later to get it. If vehicles parked nearby do not belong to a suspect, they may also provide law enforcement agencies the names of potential witnesses.

Exterior Overall Photographs—Evidence

Fig. 3.16A, shows a burglary scene, with many shoe prints in the dirt outside the residence. The evidence markers are used for several reasons. Some exterior overalls may not show the evidence, or may not make the evidence obvious. Evidence markers can document the evidence within the scene when the evidence is not obvious. Evidence markers can also show the evidence in relation to other items of evidence or in relation to fixed features of the scene or to structures. In this case, there were two different shoe print patterns, and two types of evidence markers were used, A-frames and cones, to show the paths of each shoe print pattern.

Fig. 3.16B, shows a smaller area of evidence outside the same residence. Again, the evidence itself is not as obvious without the markers.



FIGURE 3.16
(A) Burglary scene: shoe prints in dirt. (B) Burglary scene: shoe prints in dirt.
Courtesy of Criminalist Rebecca Shaw, Arapahoe County Sheriff's Office, CO.



FIGURE 3.17
Exterior overall—evidence.

Fig. 3.17 shows the view of an area of dirt beneath a balcony which was the entry point to a homicide scene. The ladder legs can be seen in the dirt surrounded by shoe prints. These same shoe print patterns were found on a nearby ladder's steps and on the victim's kitchen floor, just a few feet from the victim's body. Once a suspect was developed and arrested, this same shoe print pattern was located on his station wagon's rear bumper, where the suspect had loaded stolen property into his vehicle. Although the shoes themselves were never recovered, linking the shoe print pattern to the crime scene and the suspect's own vehicle was just another method of placing him at the homicide scene.

Taking exterior overall photographs at the beginning of the crime scene documentation is also productive because these locations are usually open to the public's view and not usually subject to any possible subject's reasonable expectation of privacy. A search warrant may be necessary for the search and seizure of evidence within buildings and residences. The exteriors of buildings, however, are frequently not regarded as restricted areas requiring search warrants, unless they fall within the curtilage of a residence. While the search warrants are being secured for protected exterior areas and interior spaces, much is to be done outside that does not suffer from similar restrictions.

Interior Overall Photographs—Crime Scene

Once the legalities of entering possibly restricted areas have been addressed, taking interior overall photographs is usually a priority because the scene will have to be documented "as found" before anything can be moved. Depending on the nature of the crime being investigated, many rooms may need to be photographically documented, or just one room may need to be photographed. **Interior Overall Photographs** are the bridge between the exterior overall photographs and photographs of the individual items of evidence within the crime scene. After the exterior has been photographed and before the evidence is photographed, the interior is photographed.

At times, walking through an exterior door will put you into the crime scene room. Other times, when you enter the building initially, you will be in a room that is not the crime scene, or you will find yourself in a hallway or lobby. Depending on the nature of the crime, you will have to decide whether each of these other rooms, hallways, or lobbies will also have to be photographed to adequately document the full extent of the crime scene. Preference should be given to the use of a "normal" lens for most of this photography. It will capture these areas as you saw them. The "normal" lens will neither compact relative distances nor elongate the size of any room.

Again, a wide-angle lens can be used in these circumstances, if you intentionally attempt to exclude as much foreground as possible, because it is this foreground that will tend to be noticed as elongated. The wide-angle lens, however, becomes the tool of choice when in small rooms or small enclosures. Bathrooms, kitchens, garages, work areas, and any other similar areas call for the use of a wide-angle lens! Otherwise, the use of a "normal" lens captures such a narrow view of a small scene that an unusually large number of photographs may be necessary to document the room in a 360-degree sweep.



FIGURE 3.18
Left: building exterior door. Middle: hallway to crime scene room. Right: door to crime scene room.
Courtesy of GWU MS student, D. Rio.

Should you decide to photograph the entire route from the exterior door to the crime scene room, the images of Fig. 3.18 show representative examples. The camera should be turned vertical for subject matter that is taller than it is wide, as are most doors. If doors have distinguishing numbering or lettering, be sure to include this information. If a door is closed, partially open, or wide open, make sure to photograph it "as found" before moving it. It is a good recommendation to photograph a door from the outside before entering through it and then to photograph it from the other side after walking through it. There may be evidence on either side of the door. The extent of the crime scene will dictate whether this needs to be done.

Once inside the crime scene room, take a complete set of interior overall photographs. The phrase "interior overall photographs" suggests that a full 360-degree view of the room will be photographed. This can usually be done in one of two ways.

Many crime scene photographers are taught to photograph the room from each of the four corners while facing the opposite corner, which is also the way this author was originally trained. If the room was big enough so that these four shots with a 50 mm lens did not encompass the entire room, it was suggested that a wide-angle lens be used. Fig. 3.19 shows the result. This approach has become the standard taught by many law enforcement agencies.

Fig. 3.19 does succeed in capturing a 360-degree view of the room in just four images. However, because a wide-angle lens was used to capture each of the four segments, the result is that the room looks much bigger than it really is. Are these four images, as a whole, a fair and accurate representation of the scene? Some, including this author, do not believe so. In many crime scenes, the room dimensions have proved critical to a reconstruction of the scene. From position X in the room, subject Y could have accessed Z area with a gunshot or thrown knife. Had the room been a different size, this may not have been possible. Would it be sufficient to just mention the viewers of the photograph, the judge and the jury, that the use of the wide-angle lens tends to make the room appear a bit larger than it really is? Photographs have always been regarded as such strong types of evidence that the mantra "Is this a fair and accurate representation of the scene?" is almost as well known to the general public as are the Miranda rights so often repeated on television and in the movies. If the size of the room is critical to an issue before the court, an image depicting the room as larger than it really is can be justification for that image being excluded from being admitted into evidence for that trial.

To be fair, the images in Fig. 3.19, taken with a wide-angle lens, do show the relative positions of all the furniture, windows, and doors in a minimal number of images. This cannot be denied. If it were possible to separate this convenient documentation of the room arrangements from the distorted suggestion that the room is larger than it really is, these photographs would be an efficient method to take interior overall photographs. Do these images accurately show the relative arrangements of furniture and room features? Yes. Do these images accurately portray the dimensions of the room? No. Can these images be used in court and still be considered "fair and accurate representations of the scene"?



FIGURE 3.19
Interior overalls: corner-to-corner.

If the testimony includes a statement that the use of a wide-angle lens also makes the scene appear larger than it was in reality, this would take the wind out of the sails of a defense attorney's objection that the images distort and elongate the perceived distance from the photographer's position to the back of the scene.

One other possible issue with Fig. 3.19 is that the diagonal views of the room from its corners, when using a wide-angle lens, make the far corner of the room much smaller than necessary. Being smaller, these areas are harder to see. Why make potentially important areas of a crime scene room smaller than necessary? As with exterior overalls, small can be regarded as being less important, because if it were important, the photographer certainly would not have intentionally made that area of the scene small. Should there not be a balance to the emphasis placed on the interior walls?

Let us return to one of the purposes of interior overall photographs. Eventually, all the evidence within the crime scene will need to be related to the fixed features of the scene. It is these fixed features that are being photographed with the interior overalls. What is important is not to show the 360-degree view of the room in as few shots as necessary; what is important is to be able to see the fixed features of the scene as clearly as possible. Compose photographs so that some parts of the wall will seem farther from the camera, and therefore smaller than necessary, can possibly be seen as self-defeating.

Is there another way? Yes. Photographing the four walls with the film plane parallel to them is the answer this author would like to propose. In so doing, the wall at the right side of the image is as large as the wall on the left side of the image. Fixed features of the walls, doors, windows, electrical outlets, floor vents etc., are all easier to see when they are closer to the camera. Compare Fig. 3.19 to Fig. 3.20.

Yes, it now takes six images to capture the entire 360-degree view of the same room. But notice the emphasis on the left and right sides of each wall is uniform. The entire room is visible and, most importantly, the room does not look differently sized than it really is. There would be no problem answering "Yes" to the question, "Are these fair and accurate representations of the scene?"



FIGURE 3.20
Interior overalls: film plane parallel to walls.

Other photography texts suggest the size distortion produced by the corner-to-corner shots with a wide-angle lens is minimal and should not be a problem in court. Your agency will be the final arbiter of this, and you will be required to take your crime scene photographs as your agency's SOPs demand. This section has provided an alternative point of view, and if your agency's SOPs related to crime scene photography are not written in stone, you now have a choice.

Interior Overall Photographs—Evidence

There is obviously another reason for taking interior overall photographs. After documenting the interior walls of the crime scene, there may also be groupings of evidence which might benefit from a photo showing them as they relate to each other, and to other parts of the room. The distance of a handgun and several casings in relation to a deceased person's outstretched hand is one example. Just the fact that several items of evidence are close to each other is all the justification needed to capture an image of their proximity to each other.

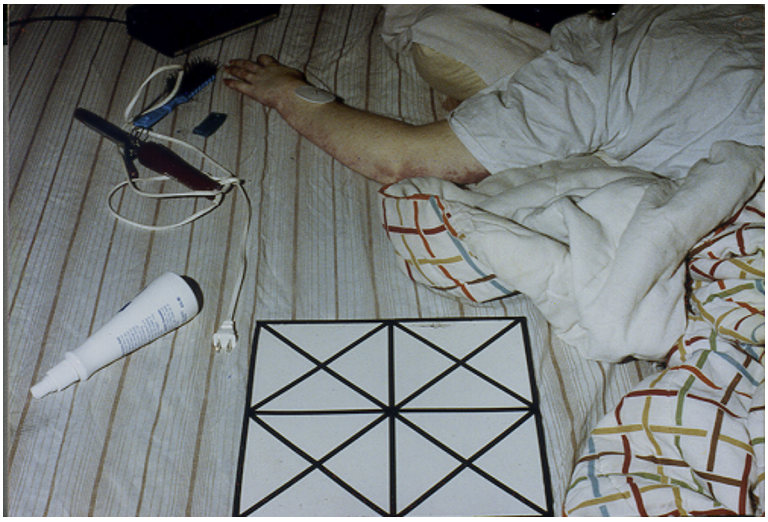


FIGURE 3.21
Interior overall—evidence.



FIGURE 3.22
Interior overall—evidence.
Courtesy of GWU MS student, K. Kinsie.

Fig. 3.21 shows the relative position of several objects near the body of a homicide victim in bed. This particular image was taken because it was believed one of the items within the photo was used to strangle the victim. As it turned out, the cord of the hair curling iron was used, and the blue hair brush was used to tighten the cord to such an extent that the handle of the hair brush broke off, and is now laying next to the brush.

Temporarily disregard the square grid showing in the lower center of the image. This will eventually be explained in the chapter on various "Photogrammetry" techniques. For our purposes here, consider it a scale which can be used in overall and midrange photos, to derive the accurate measurements of items on the same plane as it is on.

A pistol is shown as found in an area of a room with several possible items of evidence in Fig. 3.22. Of course, each individual item of evidence will ultimately be photographed in a midrange photo showing its specific relationship to a fixed feature of the scene, attempting to eliminate everything from the composition except the single item of evidence and just one fixed feature. But, before these photos are taken, there may be areas within the scene demanding to be documented because of the mini-story they tell about the scene. These types of interior overalls can encompass just a small area of a room or they may include larger areas of the room. This depends on the layout of the evidence and to what extent the photographer wants to link this evidence to other evidence or other features of the room.

Most interior overall photographs are also taken from eye level or from a natural perspective.

MIDRANGE PHOTOGRAPHS

Overall photographs are concerned with documenting the crime scene, both indoors and outdoors. With midrange photographs, you now begin to document individual items of evidence.

Before taking a series of close-up photographs of the evidence, you need to link the evidence to the crime scene. Close-up photographs will fill the frame with just the item of evidence and show various views of the evidence. These photographs will be informative only if it is known where these close-ups are located within the crime scene. It is the purpose of midrange photographs to do this job.

To the extent possible, midrange photographs should also be taken from a natural perspective. At times, this will not be possible. Again, to photograph a gun under a bed, you will need to get the camera low enough to view the gun under the bed. As a general rule, however, midrange photographs are taken from a natural perspective.

The midrange photograph is also taken immediately before a series of close-up photographs of that particular item of evidence. It is not suggested that all midrange photographs for all items of evidence be done first and then the series of close-up photographs be done next. Once an item of evidence has been selected to be documented, its midrange photograph is taken, followed by close-up photographs of the same item of evidence.

Proper Viewpoint to Avoid Perspective Distortion

When the term "distortion" is mentioned, two different kinds of distortion can come to mind:

- There can be lens distortion. A "normal" lens is usually used to avoid the distortion related to the use of different focal length lenses. As previously mentioned, a telephoto lens can "distort" the scene by compressing the foreground-to-background distance. A wide-angle lens can "distort" the scene by elongating the foreground-to-background distance.
- "Distortion" is also related to the photographer's point of view. A midrange photograph includes two items: a fixed feature of the scene and an item of evidence. Depending on the photographer's point of view, these two items can be aligned in the viewfinder in one of three different ways:
  1. They can be composed so they are parallel to the camera's sensor.
  2. They can be composed so they form a straight line from the photographer's point of view.
  3. Or, somewhere in between, they can form a diagonal line, with one item closer to the camera and the other item further from the camera.

The images in Fig. 3.23 show these variations. These first three images show the photographer, the pistol, and the radiator leg aligned in a linear point of view. In the left image of Fig. 3.33, the photographer was standing at full height or from a natural perspective. In the middle image, the photographer was stooping down a bit. In the lower image, the



FIGURE 3.23
Midrange compositions: pistol to radiator.
Courtesy of GWU MS student, D. Rio.



FIGURE 3.24
Midrange compositions: pistol to radiator.
Courtesy of GWU MS student, D. Rio.

photographer was kneeling. The pistol appears to be getting closer to the radiator leg. Not one of these three images, shown cropped together to make this point in Fig. 3.24, is to be trusted when the issue is to show the viewer a fair and accurate representation of the distance between the pistol and the radiator. Fig. 3.25A shows a diagonal point of view. The pistol and the radiator were different distances from the photographer. This point of view is better than any of the previous three images, but it is still not the preferred point of view.

In the bottom image of Fig. 3.25, both the pistol and the radiator were an equal distance from the photographer. It can be said that the camera's sensor is parallel to an imaginary line drawn between the pistol and the radiator. Another way to express this point of view is to state that the photographer intentionally formed an isosceles triangle with the camera, an equal distance from both the pistol and the radiator. This point of view, and only this point of view, depicts a fair and accurate distance between the pistol and the radiator. The other points of view have the tendency to make the pistol appear somewhat closer to the radiator than it is in reality.

Recall the image of the wheel with spokes representing diameters of the circular wheel (Fig. 3.26). When the round wagon wheel is upright, it is still viewed as a circle. Lay it down on the ground, and look at it from a perspective view, and the spokes/diagonals appear to be different lengths. You know all four wheel spokes are the same length, but only one shows the accurate length of the spokes/diameters in this perspective view.



FIGURE 3.25
Midrange compositions: pistol to radiator.
Courtesy of GWU MS student, D. Rio.



FIGURE 3.26
Wagon wheel: elliptical when laid down.

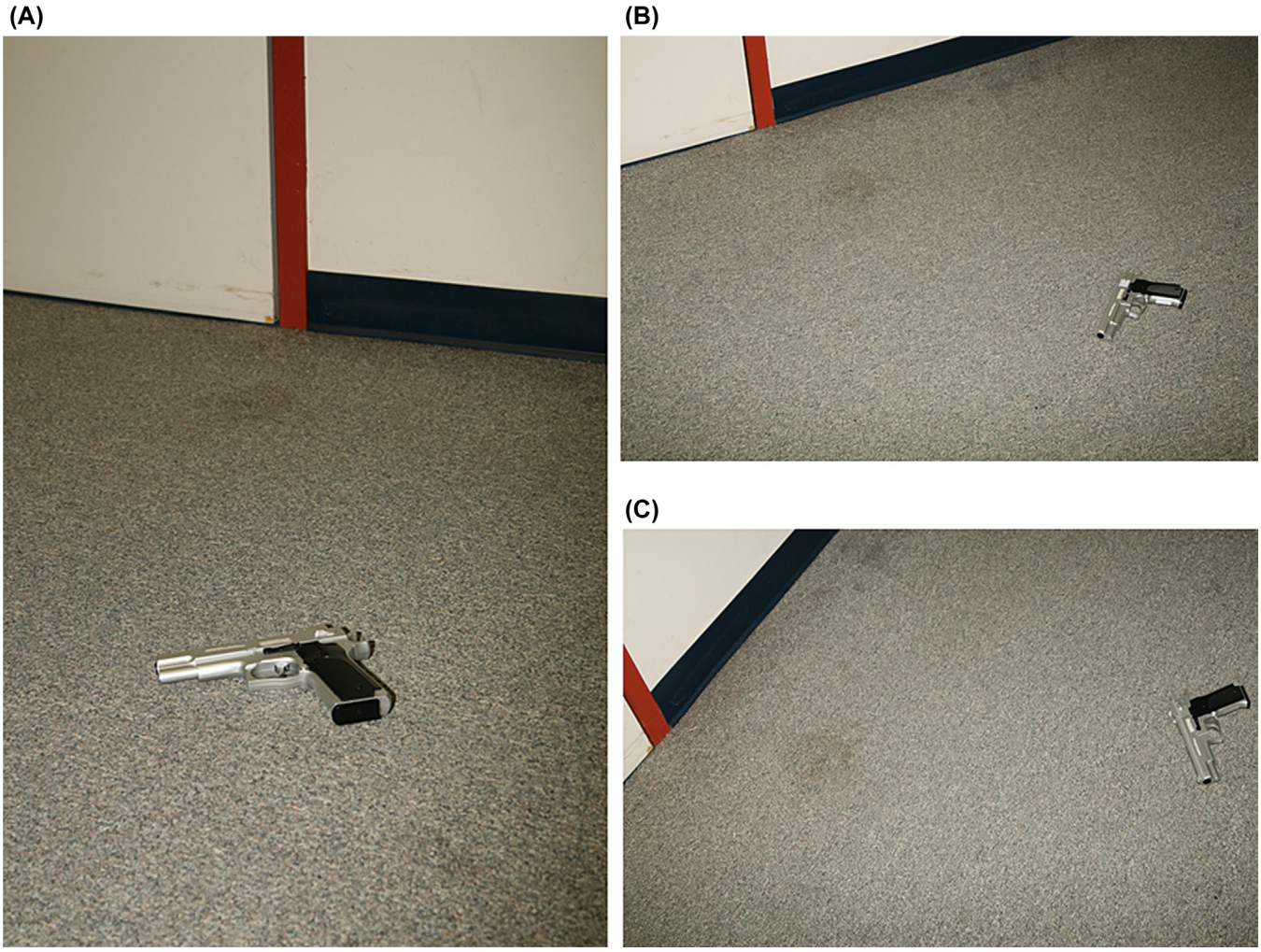


FIGURE 3.27
Three midrange views.

Fig. 3.27 shows another variation on this theme. The left image has a linear point of view. Fig. 3.27B has a diagonal point of view, with the photographer closer to the pistol than to the door frame. In the low right image, the photographer formed an isosceles triangle, with both the pistol and the door frame equal distances from the camera. Of the three images, only the Fig. 3.27C shows an accurate distance relationship between the pistol and the door frame.

At times, because of the configuration of the scene, it may prove impossible to assume this "isosceles triangle" position. Obstructions may make it impossible to get an equal distance from both the item of evidence and a fixed feature within the scene. If this situation occurs, the only alternative is to assume a variation of a diagonal point of view. If this is all that is possible, then so be it. Just remember, the more equal the distance is between the camera, the evidence and the fixed feature, the better.

Midrange Photos: Watch the Background

When the photographer is so intent to form this "isosceles triangle" point of view with a midrange photograph, other concerns should not be forgotten. In particular, students of photography seem to forget the Cardinal Rule to fill the frame with just the subject matter at hand, eliminating extraneous elements from the composition.



FIGURE 3.28
Midrange with background problem solved.

Fig. 3.28 shows an example of improper and proper compositions for midrange photographs, even when both are photographed with the film plane parallel to an invisible line connecting the scissors and fence base. Do not get tunnel vision. Do not be so concerned that the isosceles triangle point of view is established that you forget other composition ideas and include too much background in your image. The left image shows extraneous clutter in the background. The right image cleans up the composition nicely. All it took was to get a bit closer and to tilt down the camera a bit. The background distractions are gone. The crime scene photographer, who becomes known in his or her department as the "go-to" person when the best photographs of an important crime scene are required, is the one who can juggle more than one idea at the same time.



FIGURE 3.29
Two midrange viewpoints: one is better.
Courtesy of GWU MS student, D. Rio.

Fig. 3.29 presents one other concern. Sometimes, it is possible to attain the "isosceles triangle" point of view from two different directions. These two photographs show a revolver in relationship to the edge of carpeting covering a stair, but both are from different points of view. Is one better than the other? Certainly, the lower image is "cleaner" and has less distractions.

This same idea is shown in Fig. 3.30. In this case, an item of evidence indicated by the paper marker is shown in relation to a tree. Photographing this midrange photograph, while facing the street, shows a lot of equipment at a construction site in the background. Is the construction site relevant to this particular crime scene? It may be the case that the suspect or victim is somehow associated with the construction scene across the street. If this is the case, you might be able to do double duty by composing the midrange photograph with the construction scene in the background. This should be a decision you consciously make rather than the result of some serendipity. If the construction scene across the street has no relationship to the crime, it definitely should not be included in the background. Should not the viewer of the photograph



FIGURE 3.30
Two midrange viewpoints: one is better.

be entitled to make the assumption that if something appears in the image, it is there because the photographer chose it to be there? It definitely should not be in the background only because the photographer failed to consider it as a distraction.

If you have been convinced that having the film plane parallel to an imaginary line between the evidence and a fixed feature of the scene is the proper alignment for midrange photos, decisions are still to be made. These same two items, the evidence and a fixed feature of the scene, can appear in the composition high in the field of view, somewhat centered in the field of view, or low in the field of view. Why choose one or the other? If you are becoming the photographic purist this author hopes you become, you are convinced a particular photograph should tell just one story. If the relationship of

the evidence to a fixed feature of the scene is the only story that should be told in this one particular photograph, everything else that does not contribute to this goal should be eliminated from the field of view. This can often be done simply by either raising or lowering the camera. Doing so maintains the same relationship of the evidence to the fixed feature of the scene but allows the photographer to include or exclude elements in the foreground or background as required.

Figs. 3.31 and 3.32 are two sequences of midrange photographs. In each trio of images, the evidence is being shown in relationship to the same fixed feature. In Fig. 3.31 the scissors are being related to the base of a column on the right side of the image. In Fig. 3.32 the scissors are being related to the base of a chain post that has been bolted down at the scene. In each of the trio of images, the same distance relationship between the evidence and the fixed feature is documented. Each of the six images tells the story of this distance relationship. Only two of the six images, however, tell their story "cleanly," without unnecessary or distracting elements. The top image of each sequence is the "best" image. Each of the top images tells its distance relationship story, while intentionally eliminating elements that do not contribute to the intent of the crime scene photographer. It is hoped that you are not saying, "I would be satisfied with any of them." Once you see a difference between each sequence of three images, choose the one that eventually tells the viewer of the image that the photographer is extremely aware of his or her craft and composes images carefully and purposefully.

One obvious point needs to be made. In many crime scenes, both inside and outside, there can be so much clutter everywhere that it is impossible to remove all the extraneous items from the field of view. You will run into these situations frequently. In these situations, you can still use the information presented in this section to choose the composition that may be a bit less cluttered.

Lens Distortion?

When elements of a scene are aligned vertically, called a linear point of view, the photographer's perspective view alone will have a dramatic impact on the perceived distances between those near and far elements. And, as we have seen with interior overall photos of a crime scene room, another factor can result in a compromised view of the relative distance between near and far objects. Telephoto lenses will tend to compress the scene, making near and far elements appear closer together. Wide-angle lenses will tend to elongate the scene, making near and far elements appear to be further apart. Fig. 3.33 shows this effect of elongation and compression caused by using different focal lengths to capture double yellow lines.

Now, consider if these same lens effects will affect midrange photographs with an item of evidence and a fixed feature. In other words, if a midrange photograph has been composed properly, if the "isosceles triangle" positioning has been established, will different focal length lenses have the same negative distortions? No.

Fig. 3.34 shows the effect of using different focal length lenses when properly composing a midrange photograph. Because composing each shot with a different focal length lens will require the photographer to stand at different distances from the pistol and the wall corner, a slight variance in the views exists. Notice as the focal length changes from the top of the sequence to the bottom of the sequence, the view also changes from being able to see more of the top of the gun to seeing the gun from further away, which shows less of the top of the gun. The main point of this sequence, however, is that the perceived distance between the pistol and the corner of the wall does not change with the use of different lenses, when the objects are the same distance from the photographer.

How can this effect be helpful to the crime scene photographer? If crime scene obstructions or if other evidence in the crime scene prevents the crime scene photographer from composing a midrange photograph with their "normal" lens, the photographer should know that a proper midrange photograph can still be obtained by standing a different distance from the evidence and the fixed feature and composing the scene with a different focal length lens. For instance, if the composition of the pistol and the corner of the wall with a 50 mm lens would require the photographer to stand in the middle of a large puddle of blood, it is now realized that the photographer can stand closer to the evidence or further from the evidence to avoid the puddle of blood and still capture a midrange photograph depicting the fair and accurate distance between the evidence and the fixed feature of the scene.

A question always asked when on the topic of taking midrange photographs is, "Can one image be used as a midrange photograph for several items of evidence that are grouped relatively close together?" Yes. If the same fixed feature will be used for multiple items of evidence and they are all relatively close together, one well-composed shot can suffice as a midrange photograph for all the items of evidence.



FIGURE 3.31
Three midranges: which one is "cleaner"?
Courtesy of GWU MFS student, Saraya Dickson.



FIGURE 3.32
Three midranges: which one is "cleaner"?

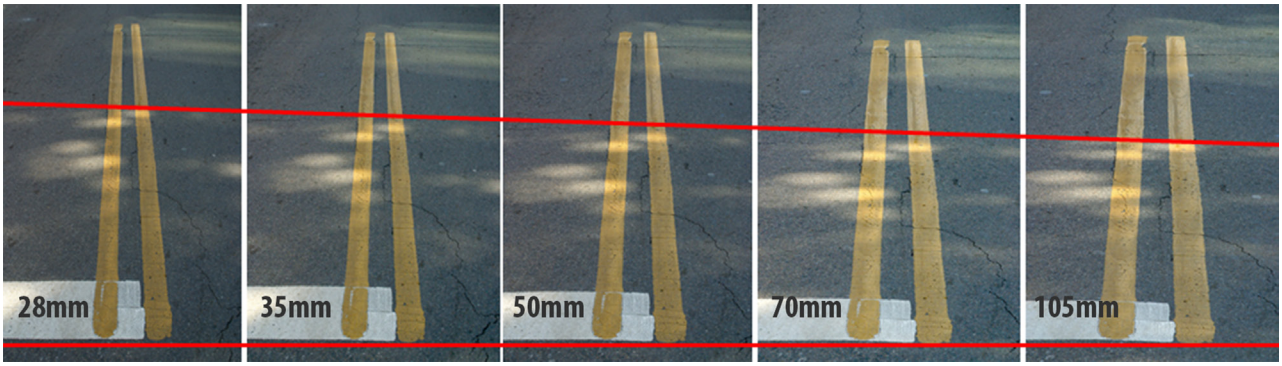


FIGURE 3.33
Different focal lengths compact and elongate vertical details.

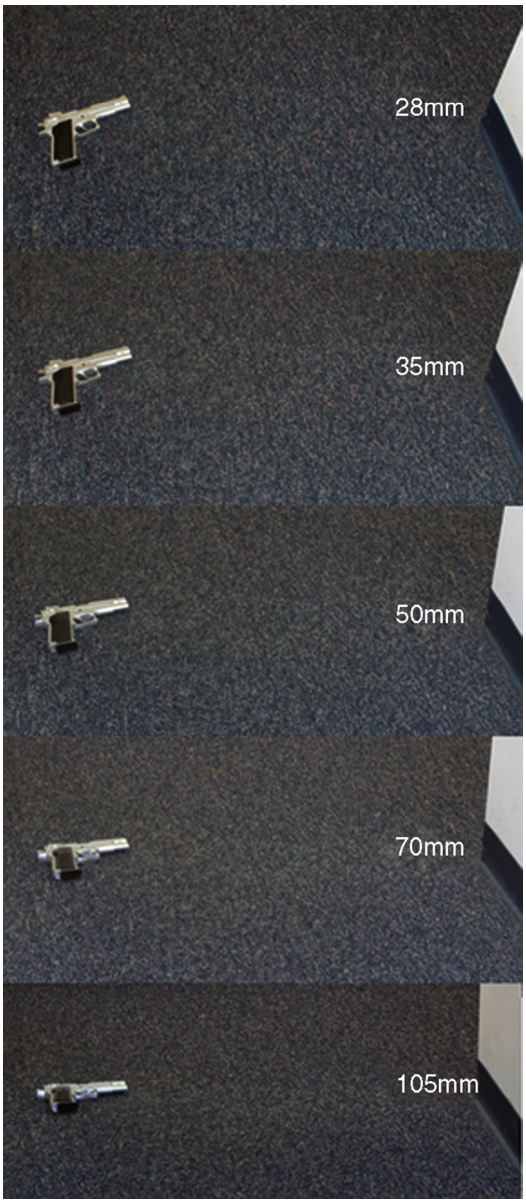


FIGURE 3.34
Horizontal details are not changed by the focal length.

CLOSE-UP PHOTOGRAPHS

To compose a close-up photograph properly, frequently the photographer must abandon the natural perspective point of view. Many times, to take a close-up photograph, the photographer will be bent over or leaning over the evidence, if not actually kneeling, to get close enough to fill the frame with the evidence.

Several types of close-up photographs exist, all of which attempt to fill the frame with the evidence. The following sections explain the four different types of close-up photographs.

Close-Ups: "As Found"

The first close-up photograph should show the evidence "as found" in the scene before any alteration or movement of anything in the scene.

Regardless of the size of the evidence, there should be an attempt to fill the frame with the evidence. If the evidence is textbook sized or larger, this can usually be done with the "normal" lens. If the evidence is smaller than a textbook, some kind of magnification will be required. Close-up filters/diopters can be used or a macro lens can be used. Some may use extension tubes to achieve magnification. Variations of close-up equipment will more fully be explained in the chapter "Focus, Depth of Field, and Lenses." No matter what close-up equipment is used, the goal is the same: enlarge the evidence so it fills the frame. If the evidence is important enough to photograph, why not make it as large as possible, so small aspects of the evidence may better be seen? If the evidence is not made as large as possible, the alternative is to include more and more of the surrounding substrate beneath the evidence in the field of view. It is best to fill the frame with the evidence rather than its background. Remember the images of the earring clasp in the previous chapter. Put as many digital pixels over the evidence rather than wasting them on the background?

When doing close-up photographs, you should invariably be using one of two apertures. If the close-up photograph will be used for comparisons with another item of evidence, then you should use f/11 and alter the other camera variables to ensure a proper exposure with the f/11. The f/11, as you will learn in the chapter "Focus, Depth of Field, and Lenses," gives a good depth of field, while avoiding image softness that can be caused by diffraction. If the photograph will not be used for examinations or analysis, you should use an f/22. There would be no benefit to using any other aperture in this case.

Fig. 3.35 shows variations of a close-up photograph of an odd looking cartridge. Why odd? One might notice that the bullet is much narrower than the casing. This may mean the bullet is encased in a sabot, allowing for a subcaliber bullet to be fired from a barrel of a larger caliber. Fig. 3.36 shows this kind of cartridge deconstructed.

Nevertheless, if both close-ups are possible, why would anyone think the Fig. 3.35A is better? It is best to fill the frame with the evidence. Why have more of your digital pixels assigned to capturing the details of the substrate rather than the evidence?

Fig. 3.37 shows a set of close-up filters being used with a column of nickels. The set of three close-up filters come with a +1, +2, and +4 magnification, and they can be stacked differently for different combinations. Fig. 3.37 shows each variation from +1 through +7. It should be noted that the manufacturers of these filters usually suggest that all three (the +7) filters should not be used at the same time because it is possible the image will be degraded with so much glass added to the end of the primary lens. This may be true, but this author has not seen the degradation warned about in any images captured with all three filters. This image degradation may become apparent when different brands of close-up filters are used.

Many photographs of items of evidence, usually with a scale in them, will eventually be used in court. Some judges and some defense attorneys may question whether the evidence was in fact originally found with a scale laid conveniently alongside the evidence. Just in case this issue ever comes up in a trial, the "**As Is**" close-up photograph can save the day. Also, it is sometimes suggested the scale may be hiding or covering some other evidence. The "as is" close-up photograph can also be used to prove this has not occurred.

Close-Ups: With a Fully Labeled Scale, on the Same Plane

The second close-up photograph that should be taken of every item of evidence is one that includes a fully labeled scale, on the same plane, and alongside the evidence, which is done for the following three reasons:

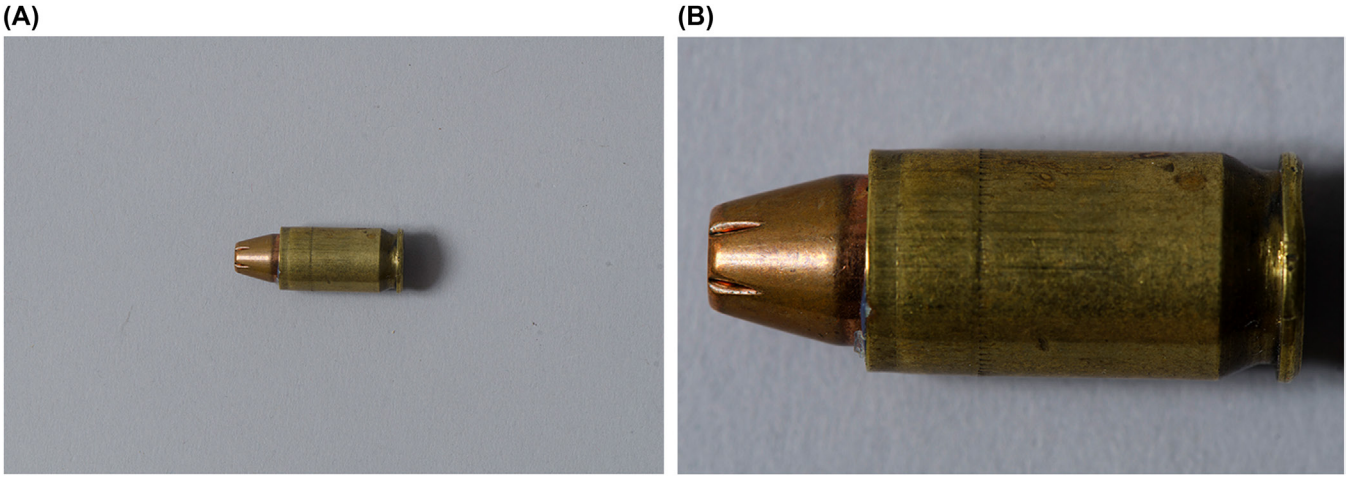


FIGURE 3.35
Fill the frame with close-ups!
Courtesy of GWU MS student, D. Rio.



FIGURE 3.36
A sabot deconstructed.

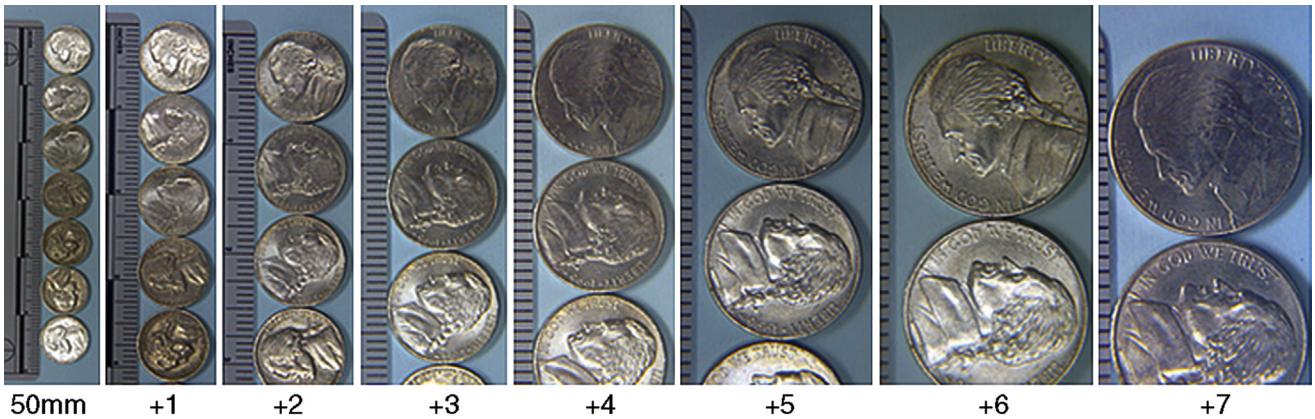


FIGURE 3.37
Close-up filters allow different enlargements.

1. With a fully labeled scale in the image, the viewer can get some sense of the size of the evidence. The size of some types of evidence cannot be appreciated without a scale. For instance, some shoe treads have the same pattern whether they are child sized or adult sized. A close-up image of one of these shoe impressions in dirt does not indicate which size the impressions are without a scale.
2. With a scale in the image, it will be possible to enlarge the original image to life size so that examiner can compare it with a known item of evidence.
3. The labeling information on the scale helps document the image. The image itself tells the viewer some details about the particular image.

Fig. 3.38 shows two variations of a fully labeled scale being used. Because it is necessary to include the fully labeled scale in the composition, it is sometimes necessary to back away a bit from evidence that is relatively small. Paint chips, fingernail fragments, or pubic hairs are other good examples of evidence with dimensions smaller than the scale. This does make the evidence appear smaller than it was in the "as is" close-up photograph, but this will be "cured" with the next type of close-up photograph. If the evidence is textbook size or larger, the addition of the fully labeled scale does not usually require making the evidence much smaller than it was in the "as is" close-up. Fig. 3.39 shows that the addition of a fully labeled scale does not have to prevent the evidence from filling the frame when the evidence is larger.

It must be mentioned again that the fully labeled scale **must** be raised or lowered to the same plane as the evidence being focused on. If the evidence is a pistol on the ground, the fully labeled scale must be raised to the height of the top of the pistol. If the evidence is a shoe print in dirt, the fully labeled scale must be lowered to the depth of the shoe impression. Recall **Rule of Thumb 3.2**: the fully labeled scale should never just be placed on the surface next to the evidence.

Close-Ups: A Close-Up Photograph With the Evidence Again Filling the Frame, but This Time With Just a Portion of the Scale in View

When photographing a small item of evidence requires backing away from the evidence to include the fully labeled scale, another close-up with just a portion of the scale in view should be taken next, which is a true attempt to fill the frame with the evidence again. This time, however, just a portion of the scale is composed in view. In this close-up photograph, the evidence should be as large as it was in the original "as is" close-up. Scale increments still need to be seen. Some scales have both inches and metric increments. It would be necessary to distinguish between the two.

Fig. 3.40A, has a small item of evidence, a Black Talon jacketed bullet, filling the frame. It also shows just a portion of the scale in view. In this case, when the composed image does not indicate whether the metric or inch side of the scale is being used, the viewer should be able to presume that the alignment of the scale is the same as the previous image, which showed the entire scale in view.

If this image were eventually going to be used for comparison purposes, the next step would be to bracket the shot with both a +1 and −1 exposure. This gives the examiner the opportunity to use the image that best shows different aspects of the evidence for comparison. Even if you are using a digital camera and can see that your initial shot was properly exposed, it is still recommended to bracket this shot. Again, sometimes it is not whether the shot was properly exposed that justifies a set of brackets. Sometimes brackets are taken to allow an examiner to choose which image best shows a particular feature of the evidence. Some aspect of the evidence may best be seen when the overall image is overexposed or underexposed.

If the item of evidence is relatively large, it may not be necessary to take this shot with just a portion of the scale in view. A shotgun, for example, will fill the frame the same regardless if a fully labeled scale is alongside it or if just a portion of the scale is in the image.

Close-Ups: The "Altered" Close-Up

Many times it will be important to take additional close-up photographs of the evidence at the scene before it is packaged. Once the evidence has been measured in place, it can be carefully picked up and inspected. Other aspects of the evidence may reveal themselves, which were not apparent when the evidence was viewed "as found." For instance, a knife may have a bloody fingerprint on the bottom side of the blade, and it was not immediately apparent "as found." In situations like this, additional "altered" close-up photographs should be taken as soon as possible. The newly discovered aspect of the evidence may be transitory or fragile, and it may not survive the packaging and transportation from the scene to the storage facility or property room. Additional close-up photography may be the only opportunity to document a newly found critical aspect of the evidence.



FIGURE 3.38
Fully labeled scales, on the same plane. Requires backing away from the evidence.



FIGURE 3.39
Here, a fully labeled scale does not require the evidence be smaller.

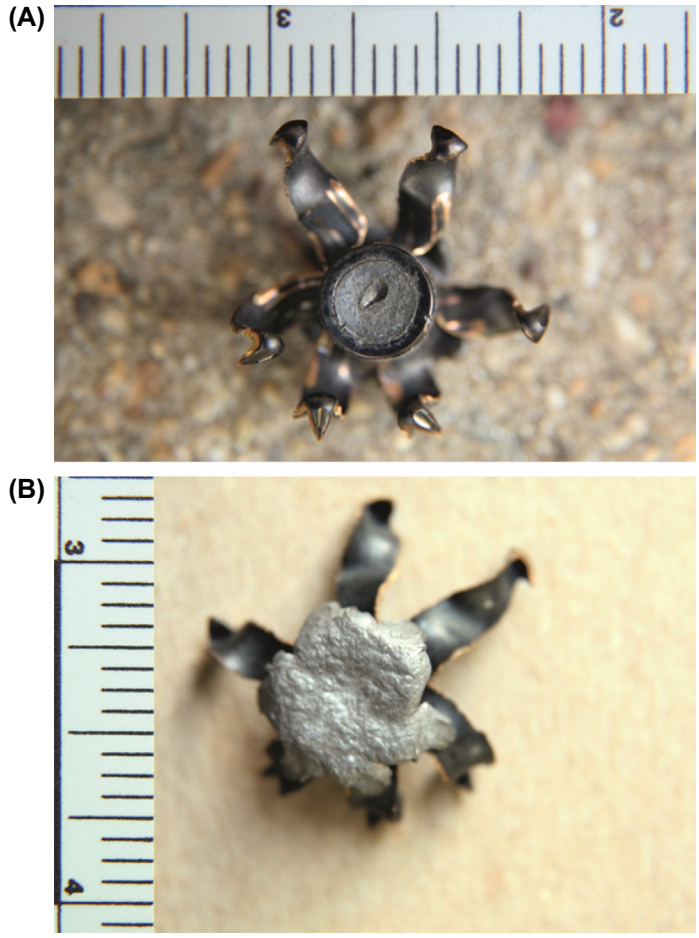


FIGURE 3.40
(A) Close-up with a partial scale. (B) An "altered" close-up, on a different background.

Another possible reason to do an "altered" close-up is that it might provide a better background than the "as is" background. If the original background was multipatterned or multicolored, it may have been difficult to see as it was originally found. If the original background was the same tone or color as the evidence, the evidence may seem to be lost against a similar background. Altering the background the evidence is on may provide a better image of the evidence for a variety of reasons.

A new Rule of Thumb presents itself here.

RULE OF THUMB 3.3

"Altered" close-up photographs should be done in a way that makes it immediately obvious to the viewer that this photograph is of evidence that has been moved. The photographer must be assured that no one viewing the "altered" photograph can confuse it with any of the "as-found" photographs.

Do **not** just roll the evidence over and take another photograph of it against the same background as it was originally photographed against. Make it obvious this next photograph is, in effect, "staged," which is usually best done by intentionally changing the background in the photograph. Rather than looking for a clean background that is naturally found in the scene, placing the evidence on plain brown evidence wrapping paper or on a brown paper bag used to package evidence is often the best choice. Packaging materials are always available at crime scenes. Plus, placing the evidence on any other surface at the crime scene may make it subject to cross-contamination. Placing it on packaging material you brought with you into the scene avoids this concern.

Fig. 3.40B, shows an example of an altered close-up photograph. This view shows the mushroomed nose of the Black Talon bullet rather than the base of the bullet. Being on a plain background, it cannot be confused with any of the other images showing the bullet at the crime scene where it was originally found. Notice that the "altered" close-up also includes a partial scale on the same plane.



FIGURE 3.41
A midrange shot, then a close-up series.

A close examination of the evidence at the scene is therefore essential. A close examination of the evidence at the scene may reveal significant identifying features, other trace evidence, or other evidence on the original item of evidence, and these features will eventually affect how the evidence is processed, packaged and preserved.

Fig. 3.41 is an example of the different types of close-up photographs that may be taken at a crime scene. Actually, the top-left shot shows a midrange photo. This is followed by a close-up "as is" and then a close-up with a fully labeled scale on the same plane. Then, there is the "altered" close-up. Notice that the other side of the evidence is now being viewed and the evidence is now on a different background. The final shot is a close-up of a bloody fingerprint on the reverse side of the knife blade, which also includes a scale.

THE PHOTOGRAPHIC DOCUMENTATION OF BODIES AND WOUNDS

Bodies at the Crime Scene

Like any other item of evidence, a body at the crime scene has to be fully documented photographically. The series of required photographs begins with a midrange photograph relating the body to a fixed feature of the scene. As with other midrange photographs, the best composition is established by having part of the body and a fixed feature of the scene the same distance from the photographer: the "isosceles triangle" point of view. The preceding sentence uses the phrase "part of the body." Why is this so? The entire body will eventually be documented in the sequence of close-up photographs that follow, so it is not necessary to have the entire body included in the midrange photograph. If it is not a problem to include the entire body in a midrange shot, that is great, but it is not necessary. The only justification for not requiring the full body in the midrange photograph is that sometimes the body is a distance from the fixed feature, and requiring the full body in the image would necessitate the photographer standing even further away, making both the body and fixed feature smaller than necessary. Fig. 3.42 shows an example of the proper positioning for a midrange photograph of a body. The fixed feature of the scene and part of the body are equal distances from the camera.

After the midrange photograph of a body, a complete **Body Panorama** series is photographed. This includes a series of photographs showing the body from all four sides. These are close-up photographs of the body, attempting to fill the frame with just the body, eliminating everything else.

Figs. 3.43 and 3.44 show the beginnings of a body panorama series. These are examples of the body photographed from the right side, the left side, from head-to-toe, and from toe-to-head photographs. Both the head-to-toe and the toe-to-head shots should be taken with a normal lens to ensure the body is not stretched or compressed. However, when taking the left side or right side views, you can use any focal length necessary. Recall the previous shots of the pistol and the wall corner (Fig. 3.34). Any focal length of lens can be used as long as the item(s) photographed are running horizontally across the field of view. When photographing the right of left sides of the body there will be no distortion of horizontal details. Fig. 3.45 shows the same right side of a body photographed with various focal lengths. The length of the body does not change when the body is horizontal to the photographer.

A full-face shot, for identification purposes, should also be part of a full body panorama series. Fig. 3.46 is the face which goes with Figs. 3.43 and 3.44. However, taking a full-face photo is not as easy as it may seem. There are four issues you should remember regarding photographing faces.

1. Filling the frame with a face can lead to facial distortion if the "normal" lens is used. We suggest using a practice known to portraiture photographers. To capture a close-up of a face, the optimal focal length to use is in the range of 100–120 mm. This allows the photographer to stand a bit further from the subject while filling the frame. With a "normal" lens, and the camera relatively close to the face, the relative distance of the nose and the ears is exaggerated and the face tends to become unattractively "stretched." The nose gets more prominent and the ears tend to look smaller than they were. Use a focal length of around 100 mm to avoid this.



FIGURE 3.42
Midrange of a body.
Courtesy of GWU MFS student, M. Eaves.

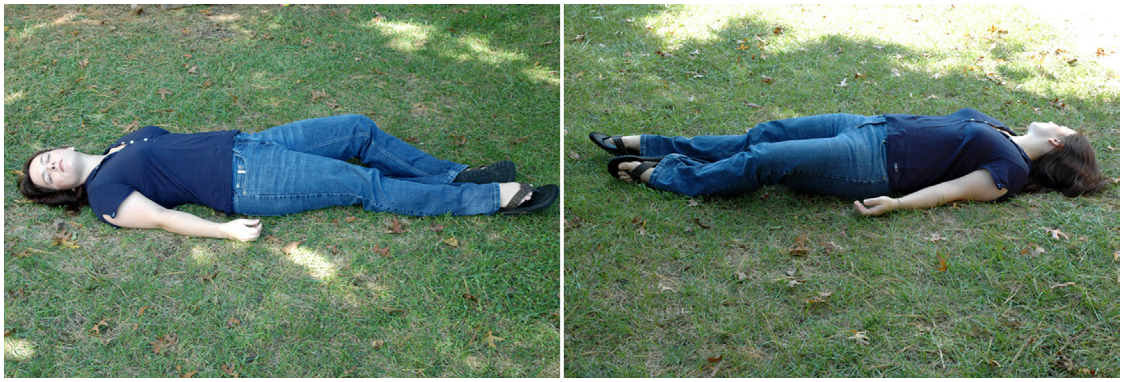


FIGURE 3.43
Right and left sides.
Courtesy of GWU MFS student, M. Eaves.

RULE OF THUMB 3.4

If you want to fill the frame with a face, while remaining back a distance that does not enlarge the nose, it is best to use a lens in the 100- to 120 mm focal length, which is the perfect portraiture lens focal length range.

This technique makes the face look like it appeared to the viewer. However, filling the frame with a face, and using a 100 mm lens to do so, becomes a bit of a problem for short photographers. While a short photographer is standing directly over the body, many 100 mm lenses have their close-focusing distance too long. This means the short photographer will not be able to focus the camera while standing directly over the victim. The simple solution is to eventually tilt the victim's head to the left or right so the photographer can stand a little further away and get the full face in focus. Of course, such an alteration of the body must be after the other "as found" photos of the body have been done and the body has been measured.

2. As with every other close-up photo, it is best to fill the frame with the face. Put your digital pixels on the face, not its background.
3. There may be times when the sun's shadowing makes photographing the face a challenge. As already mentioned, the photographer is responsible for either accepting the shadows as found; or, if they are not contributing to the success of the shot, the photographer should try to block the sun in the area of the face, so the face is completely in the shade. Then, expose for the shade.
   If indoors, the face will normally be lit with an electronic flash. With the flash, you can "arrange" the lighting of the face to eliminate distracting shadows. Or, you can add light with your flash. If this is your choice, just remember to align the flash so, as you view the face through the viewfinder, the flash is directed across the face from either a 10 to 11 o'clock or a 1 to 2 o'clock position. These angles of light across a face are the most natural. People are used to seeing faces lit from above. Even if the victim is in a prone position on the ground, you can position the electronic flash as if it is coming from 'above' the head.



FIGURE 3.44
Head-to-toe and Toe-to-head.
Courtesy of GWU MFS student, M. Eaves.



FIGURE 3.45
Horizontal body images with different focal lengths.

4. This should not be a profile shot; it is a view of the face from straight on. Slight angles to the left or right will also work. The purpose of these shots is to produce an image that can be shown to family, neighbors, coworkers, or anyone else who might know the victim and be able to identify him or her. At times, when the body is found face-down, or otherwise obstructed, one may have to wait until the body can be rolled over or repositioned before this face shot is captured. One other aspect of the face shot needs to be mentioned. One should be careful to try to have the forehead and the chin equidistant from the camera. Otherwise, one may get a lot of chin and neck, and not a straight on shot of the face.

Of course, even when the body is faced up, the face may be turned to the left or right, making this photo a challenge. In addition, many times the face cannot be taken "as found." There may be blood or hair or other reasons the face cannot be photographed filling the frame "as found." The solution is to wait for the original photos of the body to be taken, then the body is measured for crime scene diagramming (CAD) purposes, and the body can be rolled to document the other side of the body. Sometime during this time, the face can usually be arranged to be photographed with a full-face shot.

Figs. 3.47 and 3.51 provide examples of these issues. The second photo of each pairing is the "corrected" photo.



FIGURE 3.46
Full-face shot.
Courtesy of GWU MFS student, M. Eaves.



FIGURE 3.47
Full-face shot: 50 and 100 mm lenses.
Courtesy of Paul Nelson, GWU MFS student.

Figs. 3.47 and 3.48 are related to the distortion which can be caused by using an inappropriate focal length to photography the face.

Fig. 3.49 reminds us to fill the frame with the primary subject.

Fig. 3.50 reiterates the photographer's responsibility to "accept" the current shadowing on a subject or to block the sun, throwing the area into shade, and then exposing for the shade.

Fig. 3.51 emphasizes the ideal of having the face photo be taken from straight on, trying to minimize any angles.

When a body is on the floor or ground, many times the face is not positioned to be facing the ceiling straight on. The face will frequently have the chin a little higher than the forehead. To take a photograph of a face, you will want to make sure the film plane is parallel to the face, not parallel to the floor or ground. You do not want to emphasize the chin and neck. Try to have the camera an equal distance from the chin as it is from the forehead (see Fig. 3.52).

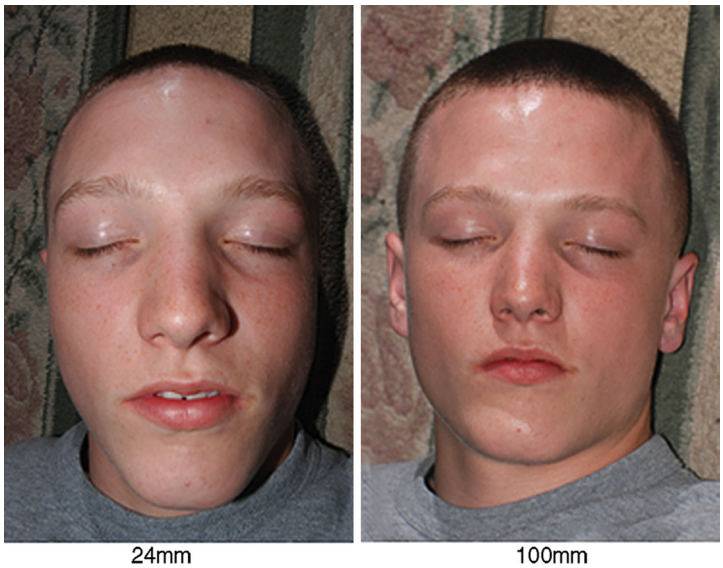


FIGURE 3.48
Full-face shot: 24 and 100 mm lenses.
Courtesy of GWU MFS student, H. Lester.

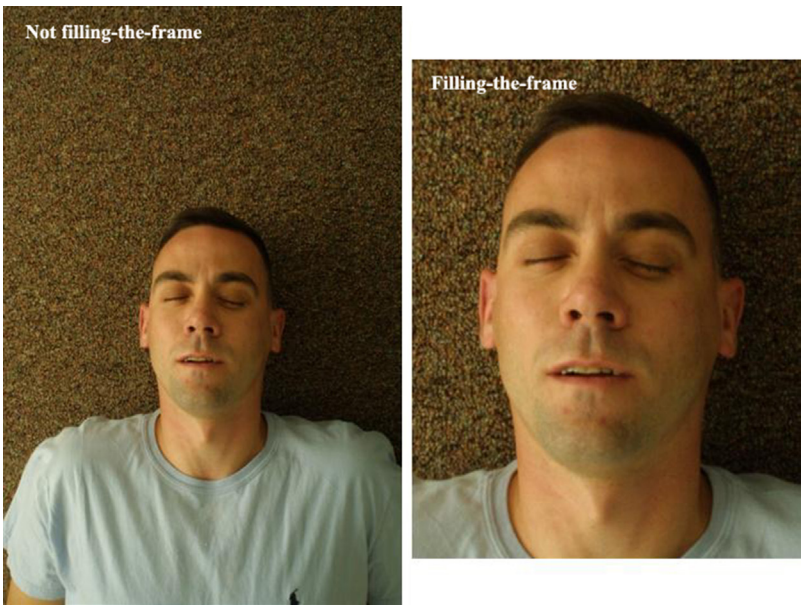


FIGURE 3.49
Fill the frame with your primary subject.



FIGURE 3.50
If the sun is throwing a "bad" shadow over a face, block the sun and expose for the shadow.



FIGURE 3.51
Try to photograph faces from straight on.
Courtesy of Saraya Dickson, GWU MFS student; Victim: GWU MFS student Bethany Pridgen.

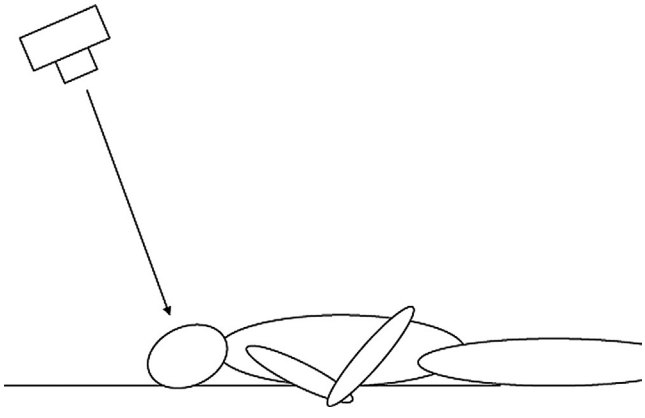


FIGURE 3.52
Have the film plane parallel to the face, not the ground.



FIGURE 3.53
Body high, in the middle, and low.

There is another issue when the body is photographed from the left or right side. When these being taken, the photographer has the option of having the body positioned high in the field of view, aligned in the middle of the frame, or positioned low in the field of view, as in Fig. 3.53. This choice will depend on whether clutter or elements not necessary for the success of the image are on either side of the body. The body remains the same. This technique allows you to exclude unwanted elements around the body or irrelevant items in the foreground or background.

When you are photographing bodies, on many occasions you cannot manage to get the entire right or left side of the body in your field of view, even with wide-angle focal lengths. Sometimes, it is just not possible to get far enough away to get the entire body in one shot. So be it. Do not get discouraged. Take two photographs of the side of the body: the top half and the bottom half. These two images will be able to be arranged so they appear as one entire body by your digital image processing software.

Fig. 3.54 shows how to align the two shots. It is not necessary to have them appear to be one original image. It is not necessary to use "stitching" software that is available on the market. It is okay to have them obviously be a composite. This work-around is another way to accurately document the scene as it was. If it took two images to capture the entire length of a body, show both of them. A hint may be useful when doing this: do not stand opposite the waist of the subject and photograph both halves of the body from this position. It is better to stand opposite the elbow of the victim when photographing the head and waist, and it is better to stand at the knees of the victim when photographing the waist and feet. Otherwise, you will see the head and feet appear to be curving away from the camera when the composite is aligned.

The shot of Fig. 3.54A is a composite of two photos taken while standing at the subject's waist. Since the distance from the photographer to the subject's waist was shorter than from the photographer to the subject's head, and likewise with the feet, both head and feet appear further from the camera in the upper shot. Fig. 3.54B was also created by overlapping two images of the top and bottom parts of the body. But the head-to-waist shot was composed from the elbow position, and the waist-to-feet shot was composed from the knees. The result is that the Fig. 3.54A approximates the top arrows, and the Fig. 3.54B is more of a straight line.

The body panorama series includes an image with the camera directly overhead. See Fig. 3.55. This is the overhead photo that goes along with the body panorama series we have seen in Figs. 3.43, 3.44, and 3.46.



FIGURE 3.54
Combining two halves of a body.



FIGURE 3.55
Overhead image.
Courtesy of GWU MFS Student, M. Eaves.

This shot may not be familiar to some crime scene photographers. It is not shot with the photographer attempting to lean directly over the victim. It is not shot while standing on a chair or ladder. The camera is placed on a tripod, with its legs and center post fully extended, and then the camera is positioned as high as possible over the body, sometimes actually touching the ceiling, if inside. This viewpoint captures the body as it will be depicted in a crime scene diagram: from a bird's-eye view. If you have access to a monopod, this can also be used for this kind of shot. One crime scene product distributor, the Lynn Peavey Corporation, also sells a modified painter's pole with a camera mount at the end of it. This would be particularly useful when the body to be photographed is further than the standard tripod or monopod can get over. Imagine a body in a bathtub, with bloody shoe prints and other evidence on the bathroom floor. With this extended painter's pole, you could photograph the body from the ceiling position while still standing in the hallway.

Fig. 3.56 shows a camera mounted normally on a tripod (the left image) and the camera mounted on the tripod for this technique (the right image). With the camera reversed as shown, the back of the camera can actually be placed against the ceiling. Two reasons exist to get the camera up against the ceiling, if the ceiling is close enough to reach. The closer the camera is to the ceiling, the more of the scene it can capture, even if it is just a short distance further away. With the camera against the ceiling, it is steadier than just hovering over the body in mid-air. The ceiling can help prevent camera shake and therefore blur.

What are the camera variables for taking this photograph?

- ISO selection: Indoors or outdoors at night or with dim lighting, use ISO 400. Outdoors, with midday sun, use ISO 100.
- Shutter speed: Use your camera's sync speed because flash will be used, whether inside or outside. Under both conditions, the speed of the flash will "freeze" the movement of the camera while in its awkward position over the body.
- Aperture: Set the camera to f/22. The camera will usually be no farther than 10′ from the body, and f/22 is the recommended aperture for flash images within 10′ with 120 GN or stronger flash units. If the flash unit indicates the flash distance is less that the height you will get the camera above the body, there are two options. Change the ISO to be one-stop faster: during the day, use 200 ISO; indoors or during the night, bump up the ISO to 800.
- Flash mode: Set the flash to the manual flash mode. If other bright lights are around the scene, or if the scene is outside at midday, flash sensors may cut the flash off early if you select any of the automatic flash modes or TTL flash mode. If any quantity of blood is around or on the body, the reflected glare from the flash striking a liquid will also cause the flash to be cut off quicker. The manual flash mode will not be affected in these circumstances. Use the manual flash mode for both indoor and outdoor scenes. If you are outside, the flash will also act like fill-flash to lighten any shadows present. The flash duration can also eliminate concerns of blur from camera shake with the camera on a tripod hovering over the body when the camera cannot be placed against the ceiling. It may be necessary to adjust the power of the full manual flash to 1/2 power, depending on the GN of the flash unit and the eventual height the flash can be held above the body.



FIGURE 3.56
Camera mounted on tripod, with tripod handle reversed.

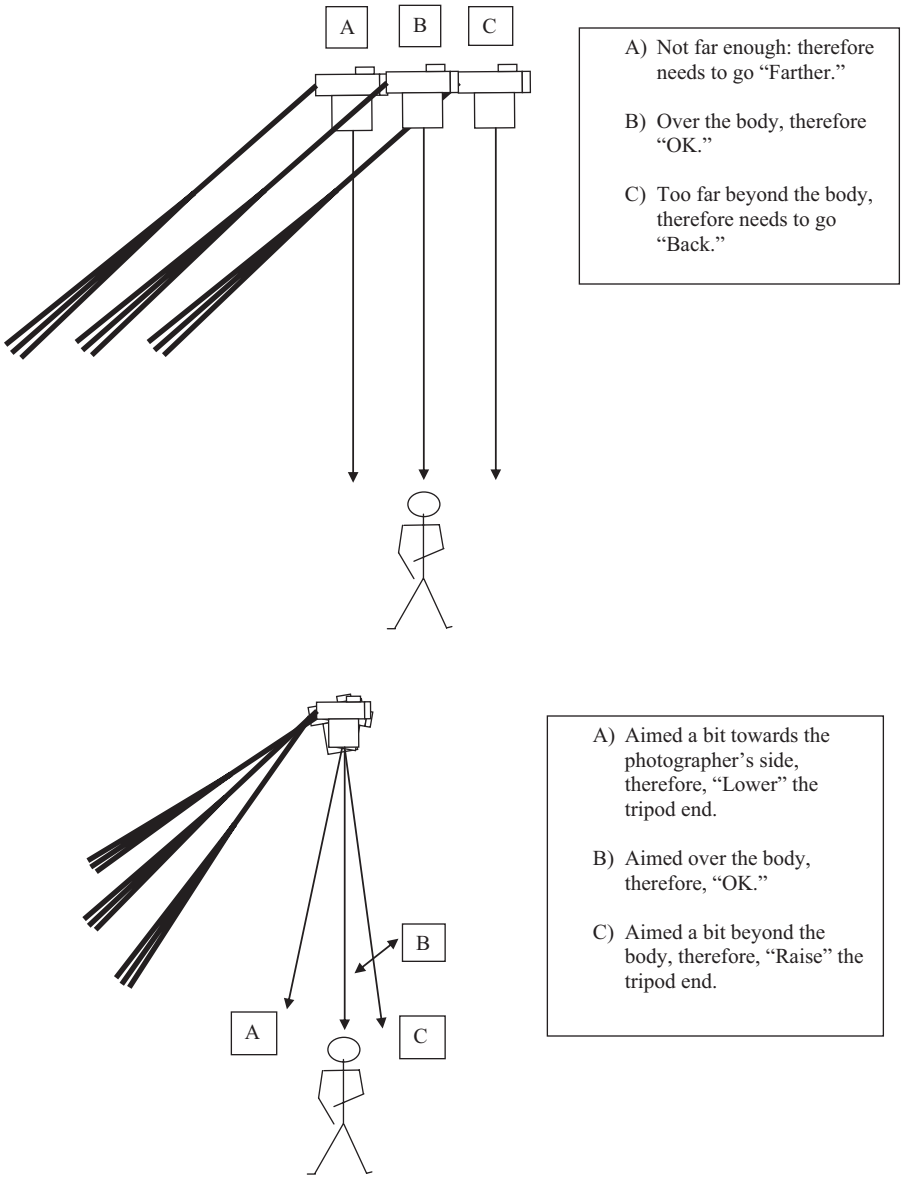


FIGURE 3.57
Ensuring the camera is directly above the body.

- Focal length: To determine focal length, stand as far **away** from the body as the camera will eventually be positioned **above** the body. From that same position, with a zoom lens, vary the focal lengths until the body is easily included in this field of view, with a couple of feet in each direction beyond the body. A full body usually requires a 35 mm lens when using a digital camera with a full-frame sensor. If using a digital camera with a focal length multiplier, begin with a 24 mm focal length, and adjust as needed. This can be variable because different photographers may be able to get the camera higher depending on their own height and arm lengths.
- Focus: You should prefocus the camera when standing as far **away** from the body as the camera will eventually be positioned **above** the body. And, console yourself that by using a wide-angle lens, the increased depth of field will mitigate for any minor focusing errors.
- Camera alignment: You should ensure the camera has its film plane parallel to the body and the camera is over the midpoint of the body. An assistant can help ensure the camera is properly positioned over the long axis of the body, whereas it is usually easy for the photographer to visualize the midpoint from head to feet. Fig. 3.57 indicates the wording the assistant standing on the long axis of the body will use to correct the original position

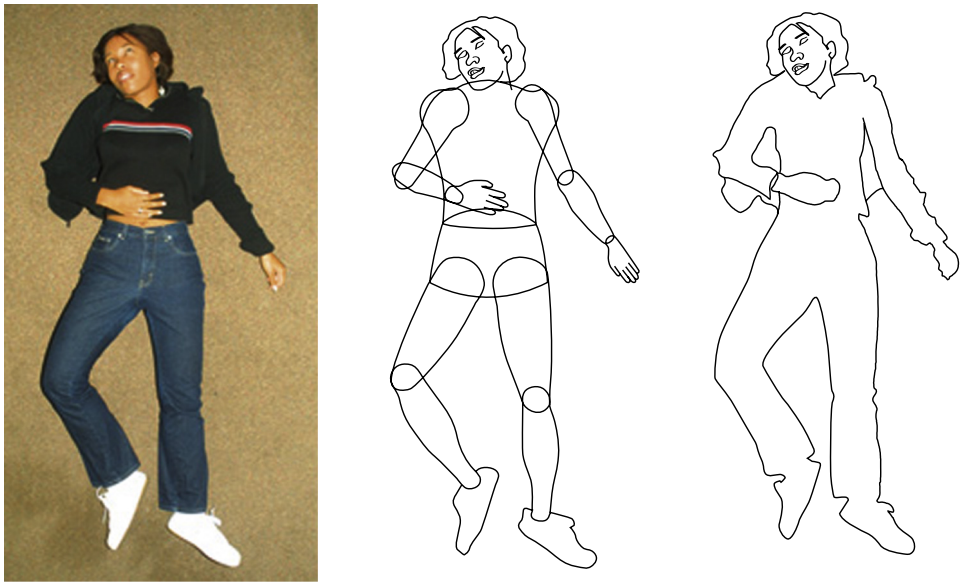


FIGURE 3.58
Overhead image.

of the camera. The photographer cannot tell whether the camera is positioned exactly above the body. The assistant can help get the camera over the body and ensure the camera is aimed straight down over the body.

- Delayed shutter release: A 10-s delayed shutter is set to provide time to properly position the camera above the body.

Fig. 3.58, left, shows the result of this effort, a great addition to the body panorama series. Another use for this overhead shot is to help produce a more realistic crime scene diagram. Instead of using the bodies provided by some CAD programs, some software programs, like Crime Zone, allow you to trace the body of the victim and place the tracing into the crime scene diagram. This makes the victim more "real" than just using stick figures in a diagram. It is also a benefit if there are multiple victims within the scene and helps reduce confusion about where different bodies were within the crime scene.

Fig. 3.59 shows the positioning of the photographer's hands as they hold the tripod to take overhead images. With the flash mounted on the camera's hot-shoe, the camera/flash/tripod combination can become heavy enough to give some photographers doubts about your being able to hold the camera over the body for 10 seconds until the shutter trips. Finger strength should not be crucial to the success of this type of photograph. Fig. 3.58A shows a photographer with her right elbow on the lower end of the tripod legs. The tripod is now supported by bones, not finger muscles. The assistant could open both hands and the tripod would remain where it is because bones are supporting it.

The lower image shows the photographer holding the tripod with just finger strength. Do not rely on finger strength. Of course, it is suggested you still wrap your fingers tightly around the tripod legs, but it should not be mere finger muscles that are supporting the tripod.

Fig. 3.60 shows the camera placed over the body with this technique, and the resulting image.

Quite a nice addition to your portfolio of body shots!

After the photographic documentation of the entire body "as found," documenting the wounds or injuries to the body is next in order. Here, it must be mentioned that to see wounds, you frequently need to alter the body's position or to move clothing around. You must be careful to do this while following the guidelines of your local medical examiner or coroner. Some have strict prohibitions about altering the body's position until they are present and have given permission to do this. Always comply with their mandates.

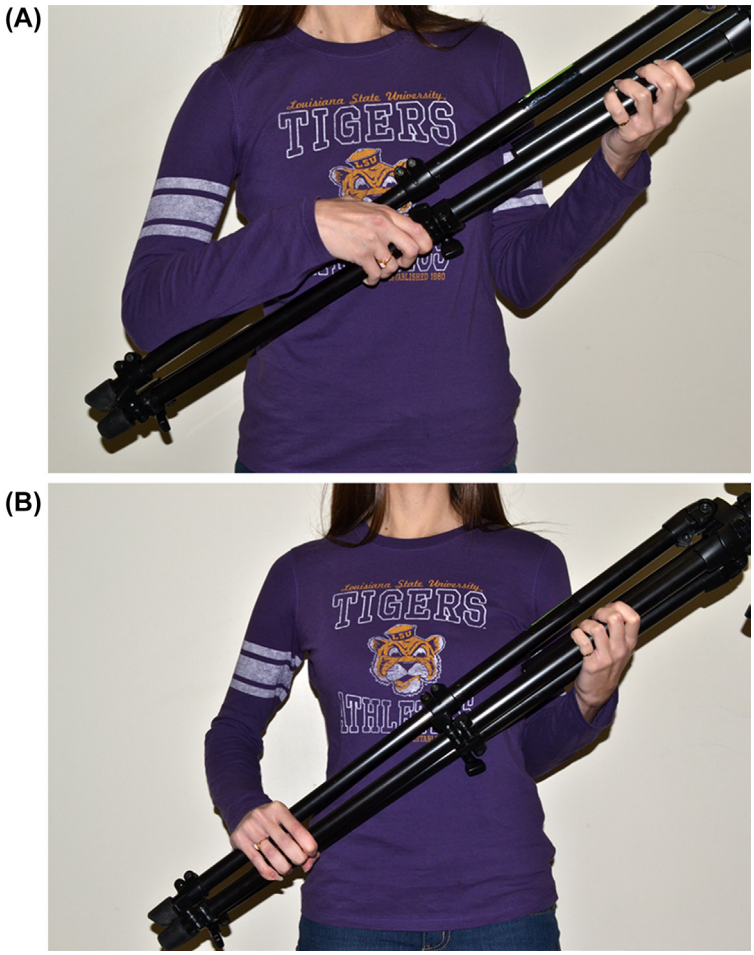


FIGURE 3.59
Hands on tripod for overhead shot.



FIGURE 3.60
Overhead collage.
Courtesy of MS student D. Maslanka.

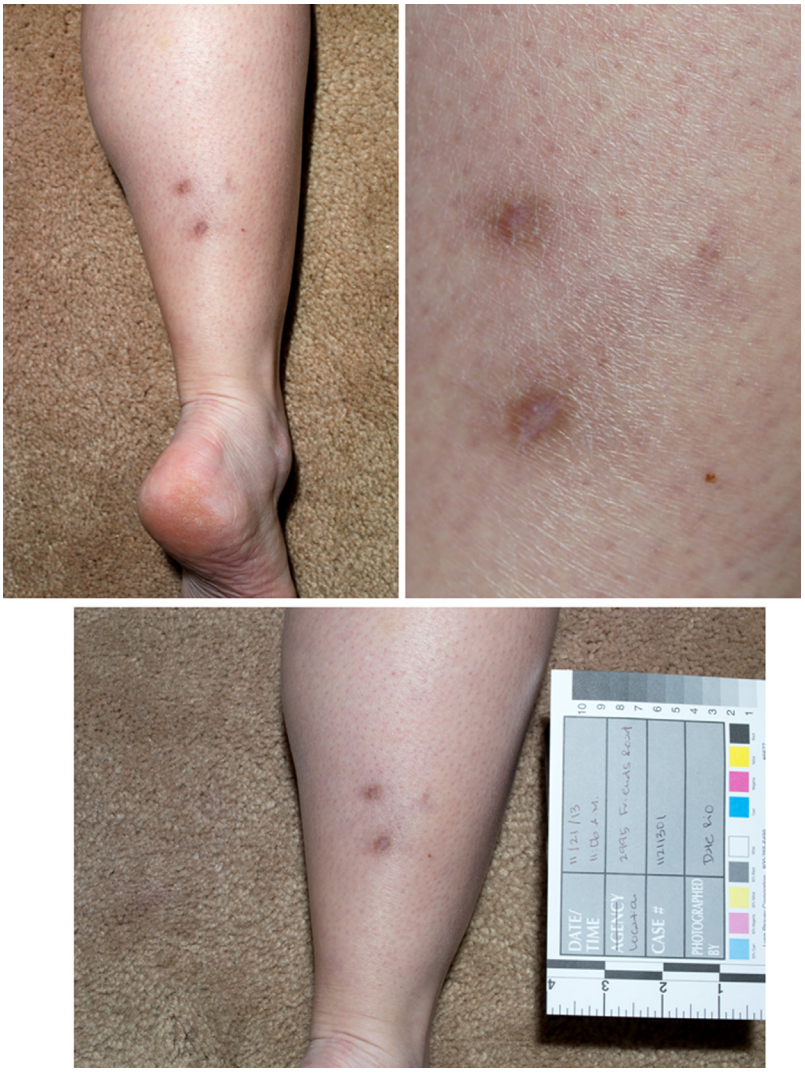


FIGURE 3.61
Wounds to a calf: midrange and close-ups I.
Courtesy of GWU MS student, D. Rio.

As with all types of evidence, the complete documentation of a wound begins with taking a midrange photograph. The body, however, has already been photographed in its relationship to the crime scene. With a wound, it is necessary to take a midrange photograph of it showing the wound's relation to a fixed feature of the body. This will normally be a joint, like a wrist, elbow, knee, or shoulder. Once the close-ups of the wound begin, it is essential that the location of the wound's position on the body has been documented. The midrange photograph does this.

A close-up "as is" is followed by a photograph with a fully labeled scale. See Fig. 3.61. Then, a portion of the scale is included in a series of exposures, bracketed 0, +1, and −1. Fig. 3.62 shows a grouping of this sequence. Again, even if you are using a digital camera and can see that the first exposure was "correct," it is still recommended that you complete the series of photographs with brackets.

When taking photographs of wounds, you must keep several exposure issues in the back of your mind.

If you fill the frame with Caucasian skin, this is quite a bit lighter than the 18% gray scene the camera's meter is expecting. The same applies for the use of automatic and dedicated flash modes. These also expect a scene that reflects 18% of the light that strikes it. The usual result will be an underexposed image, which is the result of the "dirty snow" phenomenon. The lighter scene reflects more light toward the relevant meter/sensor. The meter/sensor wants to provide an exposure for 18%. Receiving more light than that, the meter/sensor will force the camera operator to set an exposure setting that will result in an underexposure, unless corrected by a smart camera operator. Filling the frame with Caucasian skin normally requires an exposure correction of +1. This will be further explained in the next chapter "Basic Exposure."

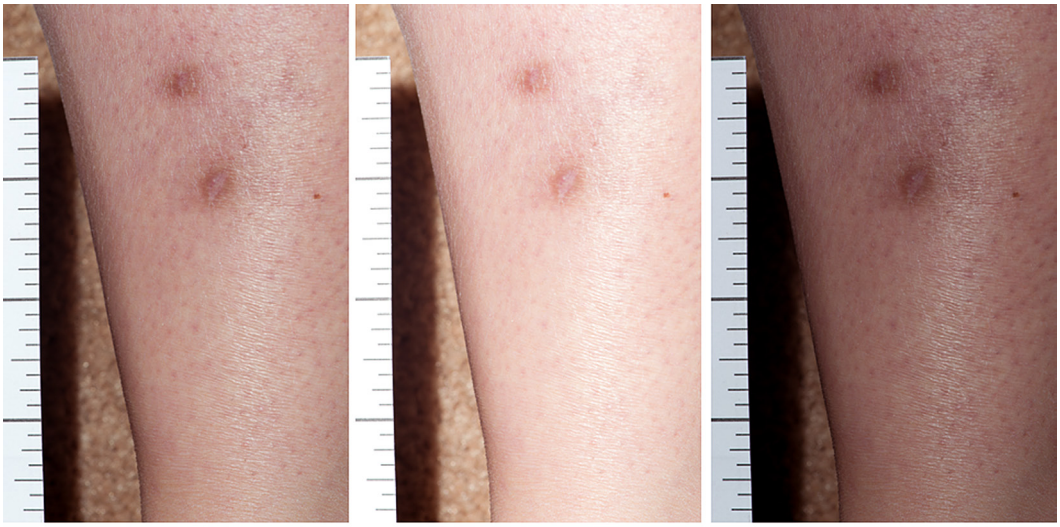


FIGURE 3.62
Wounds to a calf: close-up brackets.
Courtesy of GWU MS student, D. Rio.

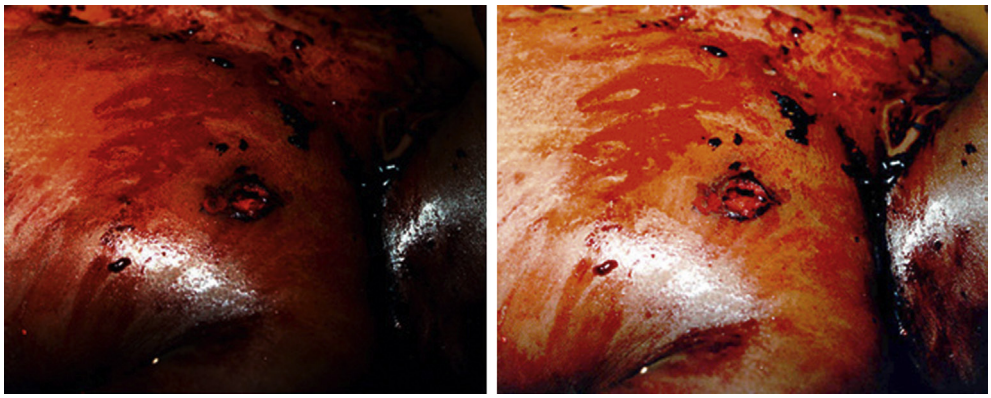


FIGURE 3.63
Bloody gunshot wound; original and +1 exposure.

Skin much darker than 18% gray will require exposure compensations on the negative side. When in doubt, bracket. Very dark skin should be exposed with –1/2 and –1 brackets.

Wounds are frequently bloody. If blood is in the scene, it will reflect more light than normal scenes. It is not the red color of the blood that is the issue. It is the fact that the blood is a liquid, and all liquids reflect much more light than normal nonbloody items. Think of blood as being similar to a chrome bumper. When light strikes it, there will be a hot spot of glare. The result is underexposure, as in the left side of Fig. 3.63, which shows the bloody area around a stab wound. Select an exposure compensation toward overexposure. The right side of Fig. 3.63 was taken with a +1 exposure compensation. If using flash, consider using the manual flash mode, which will not turn off the flash early because of higher amounts of reflected light.

Another trick to help prevent the strong direct flash from causing underexposures is to soften the flash somehow. Two methods are readily available. Adjust the flash head to a wider angle of view. If using a normal lens, consider setting the flash head to 35 mm or even 28 mm. Or, consider the use of the wide-angle flash diffuser that clips on over the flash head. Either, or both, of these techniques may help prevent underexposures. This may seem odd because the use of a wide-angle flash head and/or the diffuser reduces the flash intensity. The point is that if they also reduce liquid glares and hot spots, the metering system may not be "fooled" into underexposing the image. When in doubt, bracket.

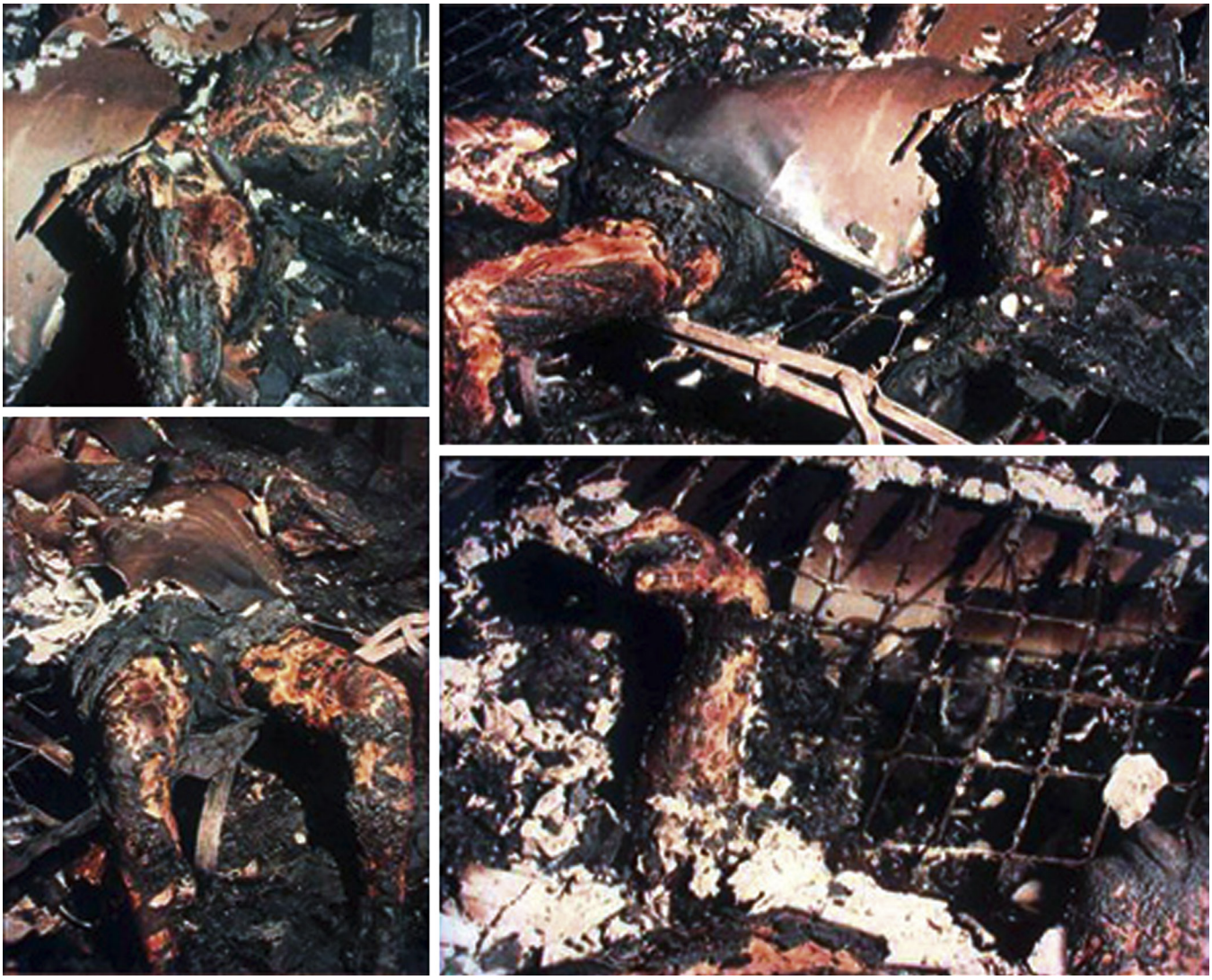


FIGURE 3.64
Fire victim in the classic pugilistic attitude.
Courtesy of Arlington County Police Department, VA.

This issue does not just apply to blood. If the skin is very sweaty or oily with lotion, these same tendencies toward underexposure must be dealt with. Or, if the body is moist because of decomposition, consider brackets toward a +1.

Besides underexposure, the issue of "hot spots" reflecting from wet skin is another issue. A trick to consider in the situation in which all previous images have captured many "hot spots" is to use bounce flash. Many times, a soft reflected light coming from the ceiling is less likely to create the glare associated with direct flash.

The opposite extreme of this reflection issue is a body that absorbs light because it is covered in soot or is itself charred black. Victims of fatal fires require extra consideration for proper exposures. If an exposure meter or flash sensor is "fooled" by the amount of reflected light returning to the camera's position, the result will frequently be overexposures. If less than the normal 18% of light is reflected from the scene, the meter/flash sensor wants to ensure the photographer gets the 18% expected and overexposes a dark scene. Again, the cure is to use the flash in the manual exposure mode, which is not "fooled" by reflected light. Always bracket in tricky lighting situations. Fig. 3.64 shows the victim of a fatal fire in the classic pugilistic attitude, with elbows and wrists bent.

After all the wounds have been documented on the body "as found," two more general categories of photographs usually must be taken before the body is rolled over, and the entire sequence of photographic documentation of the other side begins.

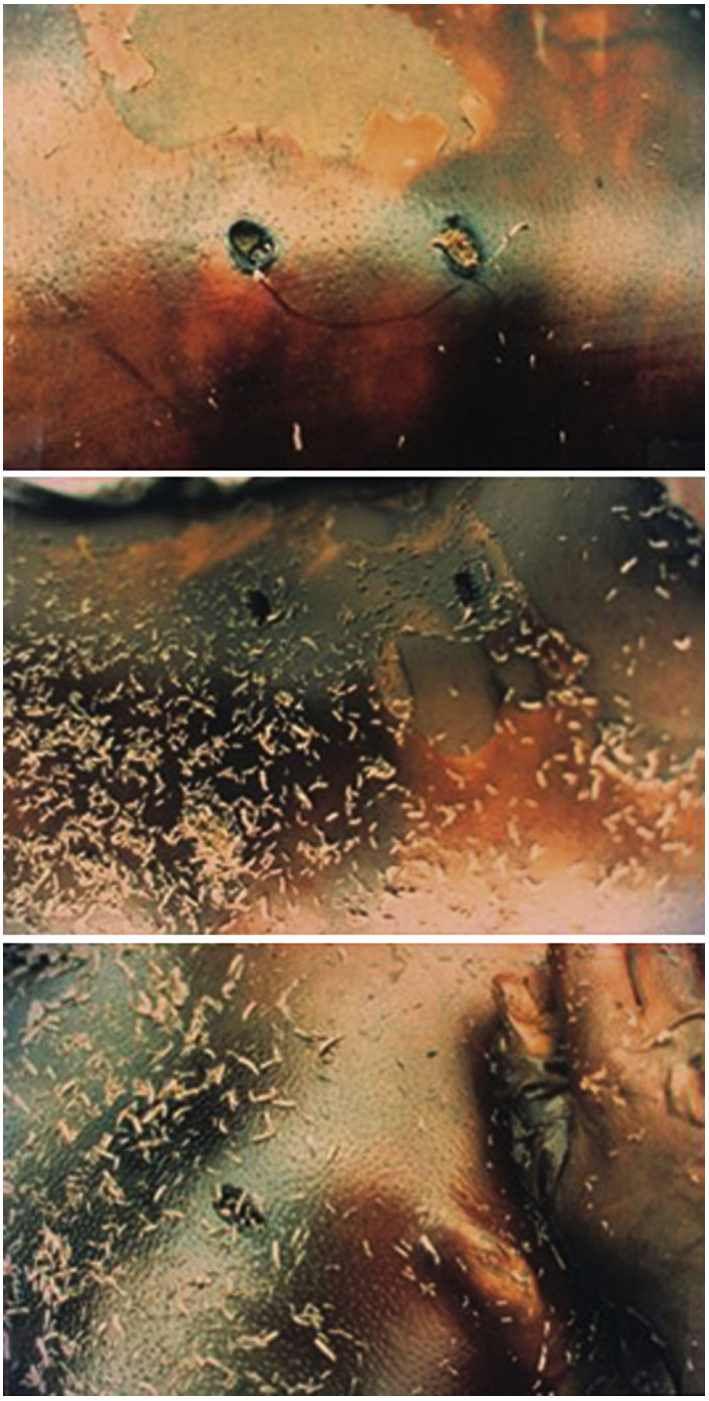


FIGURE 3.65
Insect infestation: true wounds or artifacts?
Courtesy of Arlington County Police Department, VA.

At many death scenes, the postmortem interval is frequently critical to the successful resolution of the incident. Photographically document all the clues to the postmortem interval. This may include the positioning of the body, if rigor mortis is not consistent with the body's current position. The same applies to lividity. Is it consistent with the body's current position? What color is the livor mortis? The color of lividity may indicate the manner of death. Document the body's decomposition condition. At what stage has it proceeded to? Have insects gained access to the body? Document their variety, the extent of their infestation, and signs of their long-term presence at the scene. Insects can be the cause of artifacts that can be confused with wounds, as in Fig. 3.65. Are these bullet holes, stab wounds, or holes totally or partially caused by larval activity? In either case, they should be documented with photographs. Not until the autopsy will these answers be certain.



FIGURE 3.66
Cadaveric spasm.
Courtesy of Arlington County Police Department, VA.

Look for anything that can be used to identify the body. This can be a wallet's contents or papers in pockets. It can also be engraved jewelry. And, when they are visible at the crime scene, document any scars, marks, and tattoos which may assist with the body's identification.

Are there other signs at the scene that may indicate how long the victim has been dead? Is the victim in pajamas, work clothing, or casual clothing? What looks like the last meal that was prepared? Are letters or newspapers dated? Again, it is not the purpose of this text to cover all postmortem interval signs. As your particular scene evolves, make sure to document all these issues with proper photographs.

Obviously, if weapons are near the body, they will be photographed not only in relation to fixed features of the scene but also in relationship to the body. Fig. 3.66 documents that this suicide victim was still clutching the revolver used in the incident. Cadaveric spasm ("instantaneous rigor") is sometimes confused with rigor mortis, where selected muscles immediately stiffen at death. If it is truly cadaveric spasm, the opposite arm and hand do not show a comparable stiffness.

When the top side of the body has been adequately documented with photographs, a clean sheet is usually laid alongside the body and the body is rolled onto it. The series of earlier photographs is repeated with the back of the body and the wounds that now become visible. In particular, the area that had previously been under the body is itself searched and will usually be photographically documented.

In the chapter "Special Photographic Situations," this third edition now features a new section "Autopsy Photography," where specific details related to the issues encountered with taking photographs in that environment are covered.

Sensitive Photographs

Sometimes wounds or injuries are located on parts of the body usually covered by a swimsuit. If the victim is still alive and will permit photographs of these wounds and injuries, several important concerns are related to the successful photography of this kind of evidence.

Of course, the first issue is obtaining the victim's permission to take photographs of these areas. Many may be reluctant to allow photography of their "private parts." You must remember that victims cannot be forced to permit such photographs. They must willingly allow it. Obtaining a victim's permission will often depend on the crime scene photographer's professionalism and ability to explain the need for such photographs.

One issue is whether female photographers are available to photograph female victims, or male photographers are available to photograph male victims. When possible, having a same-sex photographer will often put the victims more at ease. However, in many smaller jurisdictions, providing different-sexed photographers during a particular shift is not possible. Because of the workload, at times the only photographer currently available is an opposite-sex photographer. This circumstance will have to be explained to victims with a sensitive yet professional approach.

Explain that you understand the victims' possible reluctance to allow you to photograph their wounds. Quickly tell them that you are a professional photographer, and you understand their concerns. Explain that you have had to take these kinds of photographs many times, and one of your primary concerns is that you obtain the photographs that are required to assist in the prosecution of the crime that has been committed against them. Explain that you know they have already been victimized once and the last thing you want to do is to "victimize" them again.

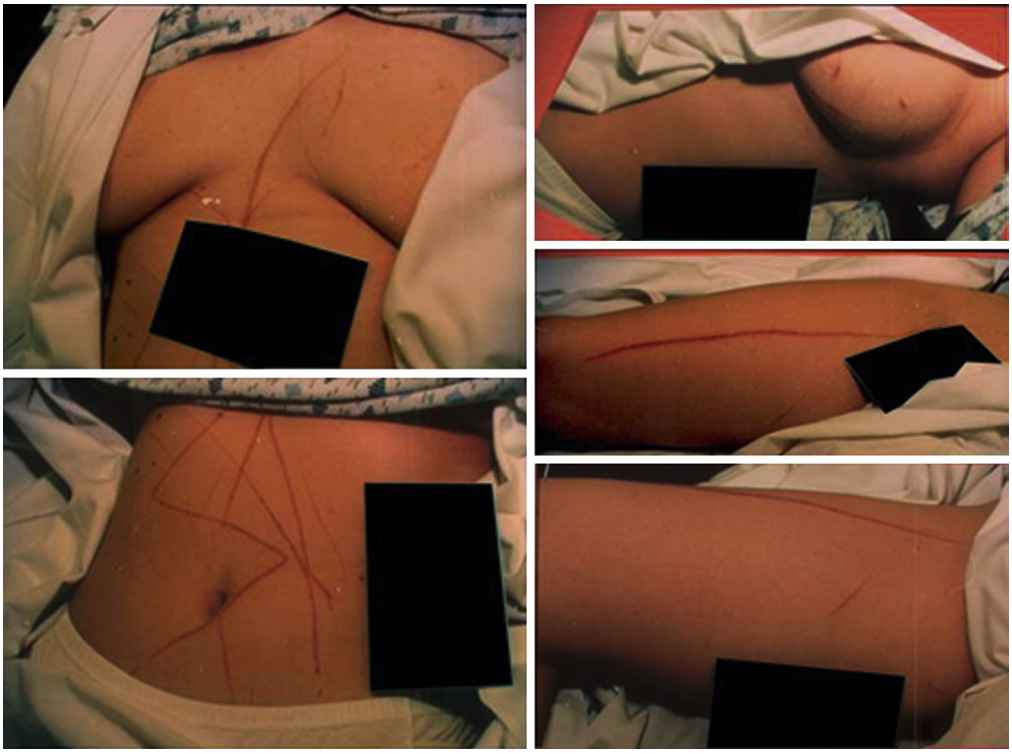


FIGURE 3.67
Injuries to rape victim.

To accomplish this goal, explain that you want the victims to feel as comfortable as possible during the process, and you want them to have someone they feel comfortable with in the room while these photographs will be taken. This person can be a spouse, family member, clergy, hospital staff, or other available friend. Ask them who they would like to have with them during this photography. Even if they do not seem to care about this issue, strongly insist on another person being in the room when these photographs are taken. You do not have to tell them this point, but having someone else in the room is also for your protection. You certainly do not want confused or vindictive victims accusing you of inappropriate behavior while they are partially undressed and alone with you in a room.

Explain one of your utmost concerns is protecting their modesty during the process of photographing their wounds. Although this should be your primary concern, the modesty of others is also one of your concerns. The judge, jury, and attorneys will also be looking at these images, and you do not want to unnecessarily offend them by showing too much skin if it can be avoided. Even if victims do not express a concern for their own modesty and are very willing to allow you to photograph anything necessary, keep these other viewers of your photos in the back of your mind and take your photographs with them all in mind.

Also, these photographs represent your professional abilities. Anybody can take a full-frontal image of a nude person, but a professional will know how to photograph what is necessary while being careful to exclude from the composition any unnecessary areas of skin.

Several investigators have expressed a wish for a single photograph of the entire area showing wounds or bruises. Usually, a series of well-placed photographs of "selected areas" will accomplish the same goal. If the victim has been cut and bruised between the neck and knees, it is not necessary to take one photograph of the body between the neck and knees. It is possible to show the entire extent of these injuries by showing a montage of several images.

Fig. 3.67 is a perfect example of several images being able to substitute for a single full-frontal image. This rape victim was also tortured by having cuts applied to her body between the neck and knees. By carefully draping her body, the photographer has ensured that the viewer of this series of images gets the full impression of the extent of the injuries to the victim. These images did not happen by accident. A very experienced photographer knows what is necessary to tell the story to the court and drapes the victim to accomplish that goal without compromising the victim's modesty or the photographer's professionalism. As a juror, would you also not appreciate this draping of this victim, while still enabling you to see the evidence necessary to establish an element of the crime?



FIGURE 3.68
Sexual assault victim.

Fig. 3.68 represents another method used to accomplish these goals, besides judicious draping, which is the composition of the images to show only what is needed. Actually, Fig. 3.68 corrects what can be regarded as a mistake. In the original photograph, the victim's face was included. In that shot, she was very upset and crying. Usually, it is recommended not to include the victim's face in any photograph of sensitive body areas for two reasons: if victims are initially told you are intentionally not including their face in photographs showing sensitive parts of their body, they may be more willing to allow the photograph be taken in the first place. Second, if victims are noticeably upset, the judge may not allow the photograph to be admitted into court as evidence if the photograph unduly prejudices the jury. A crying victim may be regarded as being overly solicitous of sympathy for the victim.

Do not just take the original image with the victim's face included; knowing you can later crop the victim's head out of the image. It is preferred that you are a better photographer, knowing how to properly compose such images, than being accomplished at correcting initial mistakes.

It is true that the victim's face should be photographed, but it should not be in the same photograph as sensitive areas of the body. How would it be established that the face belongs to the other photographs of the wounds and bruises? Try to have some common element in the face shot and in the body shots. Shirt or blouse fabric can be common to all the photographs. If the victim is wrapped in blankets or bed sheets, ensure a prominent fold in the material is noticeable in the face shot and the other body shots.

Fig. 3.69 includes two images. The left image is not the way the original image was captured; the blacked out areas were added as this image was prepared to be included in the text. The right image is the photograph that should have been taken. The incident is a rape, where the victim also sustained pinching and bruising to both breasts. The only purpose for the photograph is to document the two bruises on the breasts. In this particular case, the victim reacted spontaneously to a request to photograph the bruises by pulling up her hospital gown. The photographer, unfortunately, also reacted spontaneously and took a quick photograph without carefully arranging the photograph to show only what was necessary. Again, the right image could have been taken at the hospital; instead, a full-frontal image was captured. It should not be consolation that one can take the unprofessional full-frontal image and subsequently crop it at a later time for court.

What is wrong with the left image in Fig. 3.69?

1. The victim's face is in the same photograph as sensitive body parts.
2. Much more than the bruising is included in the composition. Would you like to have your professionalism judged by this photograph?
3. If an image can be excluded from court because it may prejudice the jury against the defendant, it can and should also be excluded from court if it may prejudice the jury against the victim. In this case, also visible in the image are tattoos on the victim's fingers. In today's climate, many tattoos with which women adorn their bodies have become socially acceptable: roses, Celtic symbols, university initials, and a myriad of other designs are so commonplace they hardly attract any attention. However, at one time, tattooed women were mostly found on the back of Harley motorcycles. The letters "L-o-v-e" on the victim's right fingers place this in this latter category

of tattoos. It would be possible for someone to see these tattoos and think less of the victim as a result. Because of this possibility, these tattoos should also have been excluded from the photograph. Actually, it is doubtful that the photographer even saw these tattoos when the photograph was taken. The image on the right is what should have been composed in the viewfinder before the shutter button was depressed.

A caution is warranted here. Do not get the impression that carelessly composed photographs can always later be cropped with digital imaging software. The defense attorney has a right to request copies of all the images related to a particular incident. That includes all the original images. A defense attorney may challenge your images, not on their factual content but on your professionalism. Whether this challenge is successful or not is moot. Having your professionalism questioned in court may be remembered by other attorneys in the court and by the judge. Do not give anyone the opportunity to do this. Far better is to develop a reputation in your agency as the person who can get a photographic job done right the first time.

Fig. 3.70, left image, shows a well-composed and intentionally thought-out image of bruising to the buttocks. It demonstrates a careful composition designed to show what the photographer wanted you to see while excluding from view any elements not essential to tell this one particular story.

This image is a "well done" for another reason. When these kinds of images are required to show injuries, wounds, or bruising, they can sometimes be done in a way that is "sexless." With this particular image, it is impossible to tell if the victim is a male or female, or an adult or child. Imagine the need to have one of your loved ones requiring such photographs. If absolutely necessary that such images be taken, would you not prefer the crime scene photographer

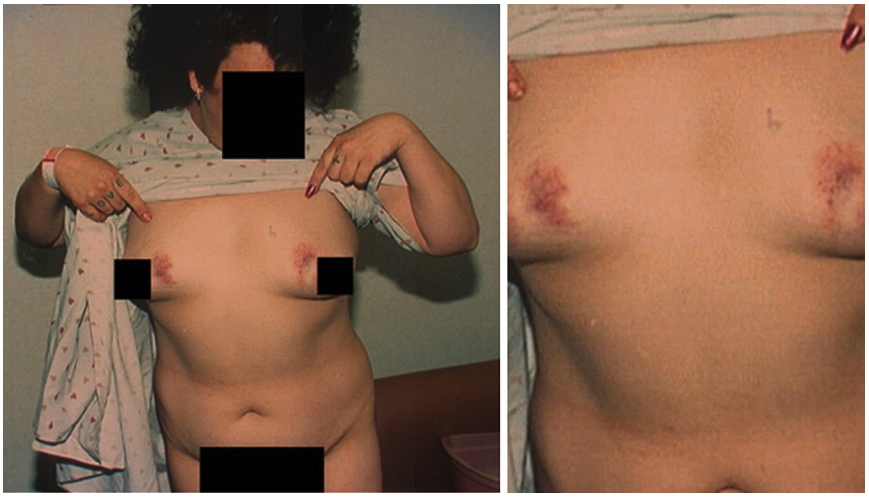


FIGURE 3.69
Composition issue: rape victim's bruises.

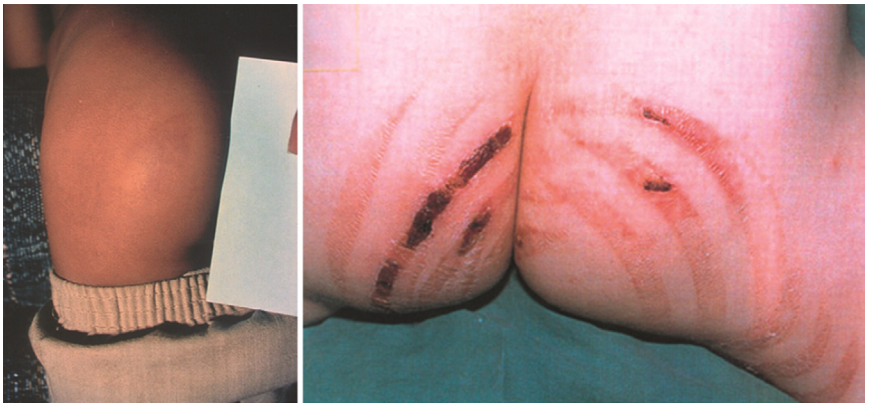


FIGURE 3.70
Left: bruise to buttocks. Right: stove-top element burns.
Courtesy of Joanna Collins, GWU MFS student and AFOSI Special Agent.

"isolate" the area requiring photographic documentation. The left image of Fig. 3.70 does this perfectly. The bruise to the buttocks is documented, but all four sides of the bruise have been cropped off or draped in some way. The viewer of the photograph must be struck with the impression that this image did not just happen accidentally; it was composed by a professional crime scene photographer. The bruise itself turned out to be the sole of a high heel shoe; in this case, a child was "disciplined" by a parent.

In one well-known situation, larger views of the undraped body may have to be shown. When a weapon, tool, or other object was used that leaves a distinctive pattern on the body, the entire pattern needs to be included in one photograph, which is the only way an examiner may be able to match a known weapon, tool, or implement back to the image. This can occur with weapons like crescent wrenches, bite marks, shoe treads, or a variety of other things. Fig. 3.70, right, shows an example of a child punished by being placed on a hot stove top. Sometimes the injury, wound, or bruise is indistinct. In these cases, imaging selected sections of the entire wound can tell the story that needs telling. If a full pattern is present, however, and this pattern may be linked to a specific item that made it, the entire pattern should be captured in the same image, if the victim allows it. In these cases, at least one image of the series taken must have a scale included alongside the pattern. This will have to be explained to the victim so he or she will give you permission to photograph larger areas than you might normally like to photograph.

Many times, fresh wounds do not show the pattern that would be useful to do a comparison to a known object. Initially, the wound may be swollen. The wound may have irregular edges. Bloody areas may make it difficult to see the wound with all its definition. At times, it is wise to tell the victim that there will need to be some follow-up photography at a later time. Coming back in a day or two, or maybe even after a week or so, may be required. Sometimes the best images of the wound or the pattern left by the weapon are most efficiently imaged on a later day. Certainly, photograph the wounds as soon as possible, but follow-up photography may be required.

LEARNING OBJECTIVES, REVISITED

Photographs can become critical items of evidence in court. As such, they must be able to withstand challenges from the defense. The careful documentation of each photograph is the best way to ensure that a photograph may survive some potential challenges. This chapter explained the three primary ways that photographs are documented.

Three basic types of crime/accident scene photographs exist: overalls, midranges, and close-ups. The overall photographs document the general conditions of the scene, both with exterior and interior views, and how the specific crime scene relates to the surrounding area and to the evidence within it.

The purpose of midrange photographs is to show a relationship between an individual item of evidence and a fixed feature of the scene previously photographed in one of the overalls. "Fixed features" are truly fixed at the scene. Inside, they are wall corners, doors, windows, and electrical outlets. They are not items of furniture that can easily be moved. A car parked in a garage is not a fixed feature because it can be moved. Outside, fixed features are street lights, manhole covers, building facades, sidewalks, curbs, and trees. They are not vegetation that is likely to change or disappear with the seasons. Midrange photographs are designed to include both an item of evidence and a fixed feature of the scene in the same photograph. It is critical to have both of these elements properly composed. This chapter recommended a technique to ensure successful midrange photographs.

A close-up photograph is an attempt to fill the frame with the evidence, with the film plane parallel to the evidence. Diagonal viewpoints are to be avoided. Examination quality photographs will be comparable to a known item of evidence only if the film plane was parallel to the evidence when the close-up photograph was taken, and a scale was positioned to be on the same plane as the evidence. The photograph should also indicate to the viewer that the photographer carefully chose the viewpoint, and diagonal viewpoints do not show this level of care.

The photographic documentation of wounds requires additional considerations not always relevant to other types of evidence. The complete photographic documentation of a homicide victim was explained. Photographing skin and bodies presents special challenges to the photographer. This chapter explained some of these processes and concerns.

DISCUSSION QUESTIONS

1. Briefly explain the written documentation that should accompany each photograph. When scales are used, explain why they should also be labeled.
2. Briefly explain the types of exterior overall photographs. Explain the issues related to the different lenses that can be used and the perspective that is suggested.

3. Briefly explain interior overall photographs. Explain the issues related to the different lenses that can be used and the perspective that is suggested.
4. Midrange photographs have a specific purpose. Explain. They, too, have lens and perspective aspects. Explain them.
5. Explain the four different types of close-up photographs that can be taken of evidence.
6. Explain the "full body panorama" series of photographs.
7. Explain the advice to "zoom in, crop, and drape" when taking photographs of "sensitive" areas of the body.

EXERCISES

1. Fill the frame with a photo identifier and photograph it both with natural lighting outside and with electronic flash inside.
2. Take a series of photographs completely documenting two sides of a building.
3. Take a photograph relating the building in which a crime occurred to the surrounding area or neighborhood.
4. Take a series of photographs completely documenting two walls of a room.
5. With an item of evidence outside, take a midrange photograph and four close-up photographs of it.
6. With an item of evidence inside, take a midrange photograph and four close-up photographs of it.
7. With a body outside, take a midrange photograph and a complete body panorama of it.
8. On this body, draw a 1″ "wound" and take a midrange photograph and a series of close-ups of it.
9. With a body inside, take a midrange photograph and a complete body panorama of it.
10. On this body, draw a 1″ "wound" and take a midrange photograph and a series of close-ups of it.

Compare your images with those in this chapter and with other images on the Companion Website (http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646) of images, referring particularly to the following image folders: body, close-ups, crime scenes, exterior overalls, interior overalls, and midrange.

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CHAPTER 4

Basic Exposure (Nonflash) Concepts

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Key Terms

Aperture
Aperture Priority Exposure Mode
Bracketing
Burning
Color Correction Filters
Critical Comparison Photographs
Dark Noise
Depth of Field
Diaphragm
Dirty Snow
Dodging
Dynamic Range
Examination Quality Photographs
Exposure Latitude/High Dynamic Range
Exposure Stops
Exterior Overall Photographs
f/16 Sunny Day Rule
f/Stop
Fill-in Flash
Focal Plane Shutter
Graininess
18% Gray Card
High Dynamic Range
Incident Light Meter
Interior Overall Photographs
Inverse Square Law
Isosceles Triangle Point of View
Manual Exposure Mode
Neutral Density Filters
Noise
Photo Identifiers
Polarizer Filter
Program Exposure Mode
Reciprocity Failure
Reflective Light Meters
Shutter
Shutter Priority Exposure Mode

Crime Scene Photography. http://dx.doi.org/10.1016/B978-0-12-802764-6.00004-0
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Single Lens Reflex
Theory of Reciprocity
UV Filter
White Balance

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the four exposure variables and their interrelationships;
2. Explain that shutter speeds are not only exposure controls but also motion controls;
3. Explain the concept of the theory of reciprocity;
4. Explain how a reflective light meter works;
5. Explain what "tools" are available to help determine the proper exposure for a tricky scene;
6. Explain the typically encountered "non-normal" scenes requiring exposure adjustments;
7. Explain the various exposure modes available with different cameras;
8. Explain how to bracket in manual and automatic exposure modes;
9. Explain the **f/16** sunny day rule;
10. Explain why long sequences of digital images may be uniformly improperly exposed;
11. Explain the basic uses of filters as lens protection, reflection and glare removers, and "sunglasses" for the lens.

THE PROPER EXPOSURE TRIANGLE

Exposure Stops

A photograph can be said to be properly exposed, underexposed, or overexposed.

A properly exposed image looks "correctly" exposed, neither too light nor too dark. It seems "normal," or as we would expect to see it. Underexposed images can seem just slightly underexposed or can progressively get darker and darker until anyone would say they are grossly underexposed. Overexposed images can seem just slightly overexposed or can progressively get brighter and brighter until anyone would say they are grossly overexposed.

In a discussion of exposures, it is also common to express the differences in exposures by using the term "**stops**." Changing exposure "stops" is an exposure change normally expressed as one that either **halves** or **doubles** the overall lighting from an original exposure. A +1 **Exposure Stop**, therefore, doubles the exposure of a previous image. A −1 exposure stop halves the exposure of a previous image. Since a properly exposed image is between a +1 exposure and a −1 exposure, taking a 0, +1, and −1 series of images means a properly exposed image is followed by a 1-stop overexposure and then a 1-stop underexposure. See Fig. 4.1.

Images can also be 2, 3, or more stops overexposed or underexposed.

The sequence of images in Fig. 4.2 show five images of a partial shoe print in dirt ranging from −2 to +2 exposures.

The concept of an exposure stop needs to be explained further. The camera's exposure system allows the photographer to precisely control the exposure of any image by manipulating several different camera variables.

Each decision to change exposures usually affects other aspects of the image besides the exposure level. For instance, changes in **Shutter** speeds affect not only the image's exposure but also the photographer's ability to either "freeze" motion or enhance the "blur" of moving subjects. Changes in **f/Stops** affect not only the image's exposure but also the photographer's ability to control the **Depth of Field** in the photograph. Both of these concepts will be addressed in subsequent sections of this text. At this point, only exposure concepts will be discussed.

Exposure Variables

Generally, four variables directly affect exposure:

1. Shutter speeds
2. Apertures
3. Digital International Organization for Standardization (ISO) equivalents to previous film speeds
4. The ambient lighting of the scene or any supplemental lighting that can be used



FIGURE 4.1
+1, 0, and –1.
Courtesy of Dale Rio, GWU MS student.



FIGURE 4.2
Shoeprint series: +2,+1, 0,-1,-2.
Courtesy of C. McGillivary, GWU MS student.

The four exposure variables can best be understood by relating them to the four sides of a triangle. Yes, a triangle has four sides. The three "normal" sides of the triangle relate to the photographic variables of shutter speeds, f/stops, and ISOs; and the "inside" of the triangle corresponds to the light at the scene, the use of electronic flash, or any other supplemental light (see Fig. 4.3). Any variance in any one of these variables results in a change to the exposure of a photograph.

Shutter Speeds

The **Shutter** in a **Single Lens Reflex (SLR)** camera is most frequently located in the camera body, just in front of the digital sensor, where light entering the lens is brought into focus on the sensor. The SLR camera is normally considered the optimal camera format to be used at crime scenes by most law enforcement agencies. There may be some agencies, however, that continue to use medium format cameras for their crime scene photography. This author also used a medium format camera early in his career. It is not the intent of this text to judge the respective merits of SLR and medium format cameras. As a matter of fact, though, most agencies have adopted the SLR as their camera style of choice.

The term "single lens reflex" involves two concepts. First, the image viewed by the photographer through the viewfinder and the light striking the sensor both come from a single lens. Second, to accomplish this dual role, the light coming from the lens is reflected (reflex) by a series of mirrors to the viewfinder. During the actual image capture, a movable mirror, "B" in Fig. 4.4, is flipped up to allow the same light seen through the viewfinder to strike the sensor.

The schematic of an SLR camera body shown in Fig. 4.4 has the sensor located in the back of the camera, indicated by "D" and the shutter indicated by "C." Because the shutter is located near the sensor, where light is brought into focus, it is called a **Focal Plane Shutter**. Some focal plane shutters open vertically (see Fig. 4.5), and some open horizontally.

The sensor is the location where the camera is designed to focus the light coming in through the lens. When the shutter button is depressed, the shutter opens for a predetermined amount of time, allowing light coming in through the lens to strike the sensor. The shutter speeds are normally indicated as whole numbers: 1, 2, 4, 8, 15, 30, 60, 125, 250, 500, and 1000. The white numbers in Fig. 4.6, from B to 4000, are shutter speed indications.

Although the shutter speeds are usually indicated by whole numbers on the shutter speed dial, or in a digital LED screen, they are, in fact, fractions. Most shutter speeds are fractions of a second. For example, the shutter speed of 15 means that the sensor will be exposed to light for 1/15th of a second while the image is being captured; 125 represents 1/125th of a second, 1000 represents 1/1000th of a second, and so on. Modern cameras have shutter speeds as fast as 1/8000th of a second.

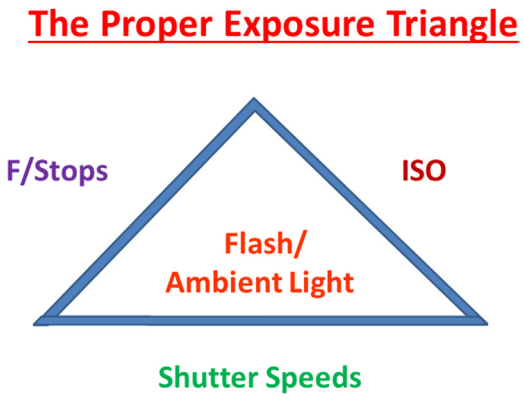


FIGURE 4.3
The proper exposure triangle.

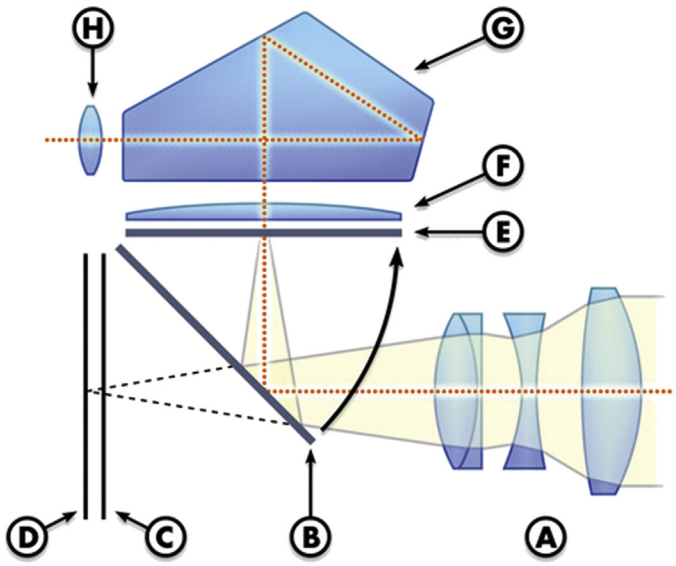


FIGURE 4.4
Schematic of a 35 mm camera. (A) Lens elements; (B) mirror-down; (C) shutter; (D) sensor; (E) mirror-up; (F) lens; (G) pentaprism; (H) viewfinder.
Courtesy of Jeff Robinson, scamper.com.



FIGURE 4.5
A focal plane shutter that opens vertically.

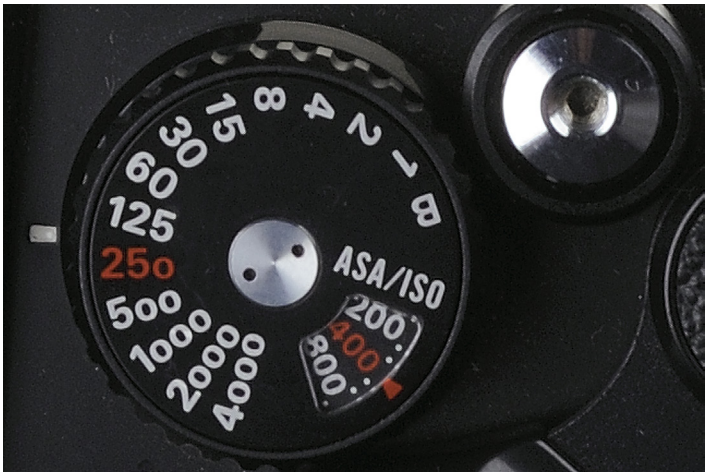


FIGURE 4.6
Shutter speed dial and threaded shutter button.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

Shutter speeds can also be longer than 1 second. To distinguish these shutter speeds from those that are just fractions of a second, shutter speeds that are full seconds are usually indicated by the inch symbol (″). For example, the shutter speed 2″ means 2 s, whereas the shutter speed indicated by 2 means $^{1}/_{2}$ s; 15″ means 15 s; 15 means 1/15th of a second. Sometimes, shutter speeds are indicated by a different color. In Fig. 4.6, the 250 between the 125 and 500 actually stands for the camera's flash synchronization speed. This will be explained further in the chapter on flash.

Fig. 4.6 has a "B" just beyond the 1-s shutter speed, and this stands for "bulb." This is the shutter speed setting used when longer shutter speeds than those available on the shutter speed dial/digital LED screen are required. When the "bulb" shutter speed has been selected, the shutter will remain open for as long as the shutter button is depressed, allowing very long exposure times. Keeping the shutter button depressed with a finger over long exposure times, however, can result in blurred images from camera shake, which is possible even if the camera is mounted on a tripod for additional camera stability.

When the bulb shutter speed is selected, it is best to use a remote shutter release cable, which is plugged into the camera body (see Figs. 4.7 and 4.8); when the shutter button is depressed, the shutter is activated. Long ago, shutter release cables had a rubber squeeze bulb on one end instead of a button. When the rubber bulb was squeezed, the shutter would trip. The term "bulb" still remains, although the rubber bulb itself is not used much anymore.



FIGURE 4.7
Electronic shutter release cable.
Courtesy of Ron Taniwaki, Nikon Forensic Services.



FIGURE 4.8
A bulb on shutter release cable.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

Any vibration associated with depressing the button on the remote shutter release cable is dampened by the flexible cable and does not result in camera shake.

Choose any number on the following continuum (1, 2, 4, 8, 15, 30, 60, 125, 250, 500, 1000, 2000), and you will notice that every preceding number seems half as large, and each succeeding number seems twice as large. In reality, it is just the opposite. For example, beginning with 60 (really 1/60th of a second), a change to 30 (really 1/30th of a second) is twice as long (sometimes referred to as "slower"); whereas a 125 (really 1/125th of a second) is half as long (sometimes referred to as "faster"). Every change along the normal shutter speed continuum either **halves** or **doubles** the time the shutter remains open, giving the photographer precise control over the time that light is permitted to strike the film, resulting in obvious exposure changes (see Fig. 4.9).

Many cameras give the photographer the option of using shutter speeds that are in smaller increments of the full shutter speeds given previously. For instance, if the camera has shutter speed increments in 1/2 stops, the shutter speed between 1/60 and 1/125 would be 1/90. If the camera has shutter speed increments in 1/3 stops, the shutter speeds between 1/60 and 1/125 would be 1/80 and 1/100. Knowing your camera's capabilities is important, because on



FIGURE 4.9
1/30, 1/60 and 1/125.
Courtesy of Dale Rio, GWU MS student.

different cameras, a change from one shutter speed to the next shutter speed may be either a full 1-stop change, a 1/2-stop change, or a 1/3-stop change. And, if your camera features exposure changes in 1/3-stop increments, it will require three clicks/adjustments of the dial controlling shutter speeds, rather than just one, to make a full 1-stop exposure change.

Increasing the length of time the shutter is allowed to remain open will cause succeeding images to be progressively lighter and lighter, tending toward overexposure. Decreasing the length of time the shutter is allowed to remain open will cause succeeding images to be progressively darker and darker, tending toward underexposure. Returning to the previous exposures of a hammer, shutter speed examples can now be assigned to each of the three images.

If a shutter speed of 1/60 led to a proper exposure, the shutter speed of 1/125 would let in half the light, and the resulting image would be darker. The shutter speed of 1/30 would let in twice the amount of light, and the resulting image would be lighter.

It will eventually be seen that all four of the proper exposure variables are in the same **half** or **double** increments, enabling the photographer to increase or decrease the exposure of the film by altering four different camera variables.

F/Stops

The **f/stop** is sometimes referred to as the **Aperture** of a lens or the **Diaphragm** opening of the lens. The three terms are sometimes used interchangeably. To be more precise, this section will explain each term.

The diaphragm of the lens is a set of blades, forming a more or less circular opening, which can be opened to let more light through the lens or closed to restrict the light entering the camera.

The aperture is the size of the resulting diaphragm opening. Apertures are said to be "wide" or "large" or "opened up" when the diaphragm produces a large opening (see Fig. 4.10, top left). Apertures are said to be "narrow" or "small" or "closed down" when the diaphragm produces a smaller opening (see Fig. 4.10, bottom right).

The term "f/stop" is actually a fraction relating the size of the aperture opening to the lens focal length currently being used and is best explained by the following equations (see also Fig. 4.10). For instance, if the lens is a 50 mm focal length lens, and the current f/stop number is 8, then f/8 basically means 50 mm/8 which results in the diameter of the diaphragm being a small circle with a diameter of 6.25 mm.

$$FLL/f/stop = DOD\ ,\ or$$
$$FFL/DOD = f/stop$$

where: FFL = Focal length of the lens
f/stop = The f/stop number selected
DOD = Diameter of the diaphragm

Again, in the case of a 50 mm lens, if the camera is set at f/8, the size of the lens opening, also known as the diameter of the diaphragm, is 50/8 = 6.25 mm. Or, a 50 mm lens with a 6.25 mm diaphragm opening is currently set to f/8. 50/6.25 = 8.

Here is another example: with a 50 mm lens on the camera and an f/4 set on the camera, the diameter of the diaphragm would be 50/4 = 12.5 mm. Or, a 50 mm lens with a 12.5 mm diaphragm opening currently set to f/4. 50/12.5 = 4. Another example: f/22 with a 50 mm lens. The lens opening would be 50/22 = 2.27 mm.



FIGURE 4.10
Various apertures.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

The following are the normal, full f/stop numbers available on many lenses: 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, and 32. These particular numbers are derived from the physics of light and will be explained later in the discussion of the **Inverse Square Law** as it relates to electronic flash.

For now, however, it is just important to remember that although f/stops are expressed as whole numbers, just like shutter speeds are usually expressed as whole numbers, they are also actually fractions. Therefore, f/8 actually represents 1/8th, and f/4 actually represents 1/4th. Although shutter speeds are fractions of a second, f/stops are fractions of the focal length of the lens being used.

Notice the relationship between the f/stop numbers and their respective lens openings. The 22 of f/22, what appears to be a relatively large number, results in a small lens opening when used with a 50 mm lens (2.27 mm); whereas the 4 of f/4, a smaller number than 22, results in a larger lens opening when used with a 50 mm lens (12.5 mm). Remember that f/22 really stands for 1/22nd and f/4 really stands for 1/4th. Now, when you realize the smaller 1/22nd results in the smaller lens opening (2.27 mm) and the larger 1/4th results in the larger lens opening (12.5 mm), the f/stops begin to make sense.

One convention of this text will be to express the term "f/stop" as a fraction, rather than the "f-stop" used by some other texts. The correct "f/stop" term serves as a constant reminder that the f/stops are a ratio of the focal length of the lens currently being used on the camera.

Budding photographers frequently point out that the f/stop numbers are not as simple to comprehend as the shutter speeds seem to be. One complaint is that the apparently larger number, the f/22, actually represents a smaller-sized aperture, whereas the apparently smaller number, the f/2, actually represents a larger-sized aperture. Again, remember that the f/22 really is **not** a large number; it signifies 1/22nd of the focal length of the lens. The f/2 really is **not** a small number; it signifies $^1/_2$ of focal length of the lens, a much larger amount than just a 1/22nd.

However, because this same issue constantly occurs with every new class of crime scene photographers, it became paramount that a definitive method was found to make the theory easy to understand. Analyzing the types of people likely to be reading this text, it became apparent that readers would likely fall into one of two general categories. Readers would likely belong to some form of law enforcement agency, whether local, state, military, or a federal agency. Or, they would be students in school preparing themselves for an entry-level career in law enforcement and crime scene processing. The solution to the problem became clear: use examples immediately understood by each respective audience.

For those aspiring to their first careers, a pizza would provide the perfect analogy, because most students survive almost totally on this food during their formal educations. Imagine being with a gathering of friends when a pizza arrives at the door.

Now, imagine having to split that pizza with your friends. If your share was an f/2 portion of the entire pizza, you would receive $^1/_2$ of the pizza, and that is a lot of pizza. If your share was only an f/22 portion of the pizza, you would receive only 1/22nd of the pizza (see Fig. 4.11).



FIGURE 4.11
The whole pizza, half a pizza: an f/2 portion, 1/22 of a pizza: an f/22 portion.
Courtesy of Brigid Reilly, GWU MFS student.



FIGURE 4.12
A dozen donuts; half of the donuts, an f/2 portion; 1/22 of the donuts, an f/22 portion.
Courtesy of Brigid Reilly, GWU MFS student.

Those already affiliated with a law enforcement agency require a different analogy for the full meaning of f/stops to truly hit home. In this case, it is natural to think in terms of donuts. I can only say that because this author is a retired police officer, so I say it with love.

Imagine having to split a dozen donuts with your coworkers. If your share was an f/2 portion of the box of donuts, you would receive $^1/_2$ of the donuts. If your share was only an f/22 portion of the box of donuts, you would receive only 1/22nd of the total (see Fig. 4.12).

When we speak to people in terms they can understand, complex ideas become simple!

The same goes for the amount of light let in by various f/stop selections: f/2 lets in a lot of light; f/22 lets in very little light.

Another important fact to remember about f/stops is that, just like shutter speeds, changing from any one full f/stop to an adjacent full f/stop number either **halves** or **doubles** the light allowed to enter the camera and strike the sensor. The difficulty is that the f/stop numbers themselves, as numbers that can be halved and doubled, do not seem to suggest this. For instance, changing from f/8 to f/5.6 increases the light reaching the sensor. By how much? By double the light. A 1-stop change of exposure either halves or doubles the light reaching the sensor. Changing from f/2.8 to f/4 would be half the light, resulting in a −1-stop change.

For now, just accept the fact that a change of f/stops that results in the next larger lens opening doubles the light entering the camera; a change of f/stops that results in the next smaller lens opening halves the light entering the camera. Be assured that ultimately the sequence of the f/stop numbers themselves does make sense, but that explanation will come later, when the inverse square law is explained in chapter "Focus, Depth of Field, and Lenses."

When considering the following images of sheers with different exposures, examples of f/stop numbers can now be assigned to them (see Fig. 4.13).

An f/8 allows precisely 1 stop more light to strike the sensor than an f/11 would. An f/16 allows precisely 1 stop less light to strike the sensor as the f/11 would. These would result in the same +1 and −1 exposures as the changes in the previously mentioned shutter speeds. The photographer has both tools to choose from to arrive at the same goal of maintaining or varying an exposure.

Many modern cameras give the photographer the option of using f/stops that are in smaller increments of the full f/stop numbers given previously. For instance, if the camera has f/stop increments in 1/2 stops, between an f/8 and an f/11 would be an f/9.5. If the camera has f/stop increments in 1/3 stops, between an f/8 and an f/11 would be both an f/9 and an f/10. Knowing your camera's capabilities is important, because on different cameras, a change from one f/stop to the next adjacent f/stop may be either a full 1-stop change, a 1/2-stop change, or a 1/3-stop change.



FIGURE 4.13
f/8, f/11,f/16.
Courtesy of Dale Rio, GWU MS student.

How do you "set" the f/stops on the camera? Many low-end cameras have f/stop selections that can be selected by rotating a ring on the lens. The lens in Fig. 4.14 has an f/stop continuum ranging from f/1.8 through f/22. The camera is set to f/8: The "8" is opposite the line doing double duty as the distance mark and f/stop mark.

On more modern cameras, the photographer uses a variety of dials and buttons, on the camera body, to select an f/stop.



FIGURE 4.14
Lens set to f/8.

Digital International Organization for Standardization Equivalents

When film was the tool all crime scene photographers used, it was rated with a variety of film speed numbers, such as ISO 100, 400, and 800. Just as film had different sensitivities to light, our current digital cameras can be set so the camera captures light in a manner similar to the previously used film speeds.

And, like shutter speed changes and f/stop changes halve and double the light allowed to reach the sensor, resulting in 1-stop exposure changes; ISO changes can also result in 1-stop exposure differences.

Commonly found film speeds were usually expressed as the following ISO numbers: 100, 200, 400, 800, 1600, and 3200. Digital cameras do not use film but have continued the convention of relating the sensitivity of their digital sensors to light by using the same ISO equivalents. However, some digital cameras may have restrictions on the ISO equivalent choices you might have. Whereas some digital cameras offer the choice of an ISO equivalent of 50, other digital cameras may only begin their ISO equivalents with 100 or 200.

These numbers are an indication of the sensor's relative sensitivity to light. Sensors that require more light for a proper exposure have the lower numbers, like 100, or sometimes even 50; sensors very sensitive to light, therefore requiring less light for a proper exposure, are designated by higher numbers, like 3200 or 6400. There are digital cameras now on the market with ISOs of 102,400! Continuing the ISO equivalents from 6400, the next 1-stop increment would be 12,800, then 25,600, 51,200, and finally 102,400. Many years ago, film was rated by the older American Standards Association (ASA) numbers, or the Deutsches Institute für Normung (German DIN) designation, but the United States has joined the rest of the world community and uses the ISO numbers now.

Like the shutter speed numbers, the ISO numbers immediately seem easy to understand: 100 ISO requires more light for a proper exposure; 3200 ISO can be used outside at night with only minimal light. These ISOs are conveniently **doubles** or **halves** of adjacent ISO numbers. Changing from 100 ISO to 200 ISO doubles the ISO number and is an indication that 200 ISO is twice as sensitive to light as is 100 ISO. This doubling of the sensitivity of the sensor to light indicates that 200 ISO would result in a 1-stop exposure increase (+1) compared with using 100 ISO for the same scene, if all other exposure variables remained the same. Changing from 800 ISO to 400 ISO is a halving of the ISO number, resulting in a 1-stop exposure decrease (−1). All things being equal, if the use of 400 ISO resulted in a proper exposure for a particular scene, changing to 200 ISO would result in a −1 exposure, and changing to 800 ISO would result in a +1 exposure.

Using faster and faster ISO film speeds eventually produced the unfortunate degrading of the image referred to as **Graininess**. The digital equivalent is called digital **Noise**. Digital noise is best explained by showing the two effects which are likely. One is an increase in contrast, where the midtones are lost, resulting in an image tending to be predominantly light tones and dark tones. Facial features loose much of their defining features, as in Fig. 4.15. The other result of digital noise is that when digital pixels get insufficient light to produce a proper exposure, many digital pixels seem to "guess" at what color they should be, with many being a random selection of colors, as in Fig. 4.16.

Knowing that the use of faster and faster ISO speeds can begin to degrade an image, it is prudent to do a small test of your camera to see where these degradations become objectionable to you. Pick any object across the room, or across a parking lot. Take a series of "proper" exposures, but each time increase the ISO speed while compensating



FIGURE 4.15
T. Busse normal and "noisy."

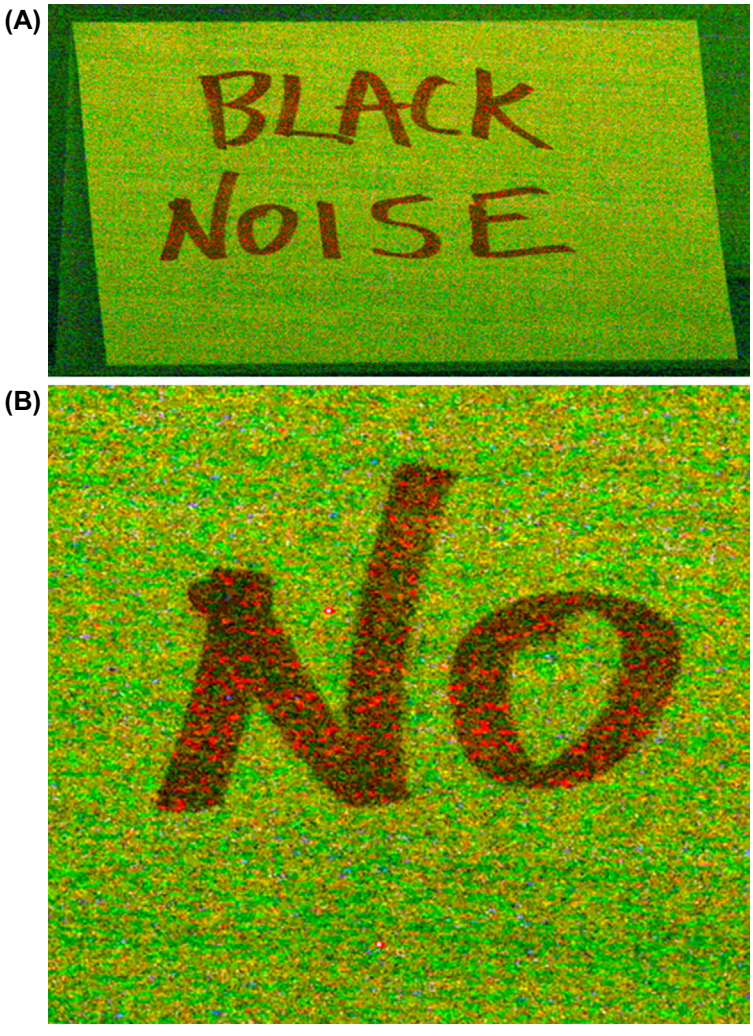


FIGURE 4.16
(A) Black noise, or (B) digital noise from an underexposure.



FIGURE 4.17
A series of ISOs and their noisy effects.

with the other exposure variables to maintain a proper exposure. You may also want to put the camera on a tripod, to ensure camera movement itself is not a factor in the resulting images. In Fig. 4.17, a car about 50′ away was selected. Each image was cropped to fill the frame with just the license plate, and this enlargement itself had some effect on the results. The exposure with ISO 400 would not appear so "soft" were it not for this enlargement. Aside from this uniform "softness" in focus, concentrate on the bumper behind the license plate. Notice how the bumper is gradually becoming more and more "grainy" or spotty. Of course, if this were just an attempt to record the license plate numbers, all the images succeed. But, where does the noise, with your camera, become objectionable to you? In this particular series of images, this author is still happy with the ISO 1600, and if pushed, I might accept an ISO of 3200. However, for my everyday photography, with my camera, I would only consider using ISO up to 1600, when necessary, for normal crime scene photography. For surveillance photography, especially at night, faster ISOs may be needed.

As in the following three images of wire cutters, all things being equal, it would be possible to vary the exposure of a scene or an item of evidence merely by altering the ISO used to capture the images (see Fig. 4.18). They were captured by using ISOs of 800, 400, and 200, respectively.

When film was still being used by crime scene photographers, changing the film speed was never a practical alternative when we had the need to intentionally produce a different exposure. Exposure changes were much more easily accomplished by changing either shutter speeds or f/stops. However, it is important to know that ISO speeds adhere to the same increments of halves and doubles as do the shutter speeds and f/stops.

The digital sensor is now the light receptor, and the image captured by the digital sensor is eventually transferred to some type of digital memory card (see Fig. 4.19). The digital memory card, however, is not the equivalent of film because it only stores the data captured by the digital sensor. Various digital camera manufacturers use many types of digital media. The competition for this niche of the marketplace is intense, and a favorite or preferred media has not emerged victorious at this time.



FIGURE 4.18
ISO 800, ISO 400, ISO 200.
Courtesy of Dale Rio, GWU MS student.



FIGURE 4.19
Various flash or memory cards.
Courtesy of Ron Taniwaki, Nikon Forensic Services.



FIGURE 4.20
Various ISO settings.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

However, it is important to note that the digital camera sensor can be rated at various ISO equivalents. Whereas the ISO of a roll of film locked the film camera operator to that film as long as it is being used, a digital camera operator has the vastly expanded options of changing the ISO equivalent **for each shot** if desired. With a digital camera, the photographer can frequently set the camera to ISO 100 for one shot, ISO 400 for the next shot, and sometimes ISO 6400, if desired (see Fig. 4.20). Digital cameras vary quite a bit with these ISO selections, so you must be familiar with the capabilities of your specific equipment. The digital camera operator has a distinct advantage when determining an exposure combination. ISO equivalents are now truly an exposure variable that can be changed as easily as the shutter speeds and f/stops.

ISO selection is usually the **first** important decision you have to make about the ultimate exposure. That decision-making process usually proceeds as follows:

1. At a particular scene, you should access the ambient lighting conditions. Is it bright or dim? If it is bright, a slow ISO digital equivalent can be used. If the lighting is dim, a faster ISO digital equivalent will be necessary. The ambient lighting dictates the use of an ISO digital equivalent that will eventually permit exposures with small apertures so that the depth of field will be adequate to have most of the scene in focus. If not, an electronic flash needs to be added. The additional light of the flash should be enough light to enable the use of small apertures for good depth of field.
2. The shutter speed is usually selected next. This will usually be 1/60 of a second because the lens most frequently used at the crime scene will be a 50 mm lens, presuming, for the moment, most are using a digital SLR camera with a full frame digital sensor. If using a digital SLR camera with a smaller digital sensor, an APS-C sensor, the "normal" focal length will usually be in the range of 31–33 mm, depending on your camera's focal length multiplier. This will be explained further in chapter "Focus, Depth of Field, and Lenses."
3. The scene is then composed through the viewfinder, and the camera's **Reflective Light Meter** is activated, usually by depressing the shutter button halfway. The meter reads the light coming in through the lens.
4. The camera's reflective light meter then determines the last element of the proper exposure triangle. With the camera aimed at a particular scene, reflecting a certain amount of light, the meter now knows (1) the light coming in through the lens, (2) the ISO setting on the camera, and (3) the shutter speed that has been selected. The meter will now suggest an f/stop that will properly expose that particular scene with that particular light level, ISO selection, and that preset shutter speed.

If the preceding four steps begin with an ISO selection decision, how is that decision made? When in doubt, rely on a Cardinal Rule: Maximize Depth of Field. How does this relate to ISO selection? At this early stage of the text, several rules of thumb will be offered.

RULE OF THUMB 4.1

Outside, during the middle of a sunny day (loosely equivalent to 10 am to 3 pm), select an ISO of 100.

RULE OF THUMB 4.2

Whenever capturing examination quality/**Critical Comparison Photographs**, use an ISO of 100.

RULE OF THUMB 4.3

All other times—early in the morning, late in the afternoon, at night, or when photographing indoors—lean toward the initial use of an ISO of 400.

Why? Because those ISO selections will eventually result in the ability to have both properly exposed photographs taken with small apertures that maximize depth of field.

How do you "set" the ISO on the camera? On many lower-end cameras, rotating a dial on the camera body sets the ISO film speed. More modern cameras have an assortment of buttons or command dials that can be pressed or dialed to select specific ISO equivalents.

Light

THE AMOUNT OF AMBIENT/EXISTING LIGHT

Ambient light is the light present at the scene. You either work with it; or, as will be discussed later, you can supplement it with an electronic flash, alternate light sources (ALSs), or flashlights. Light is a critical component in the proper exposure equation. For instance, on a bright sunny day, you may be ready to take a photograph with the camera set at 1/60 shutter speed, f/22, and 100 ISO. Your meter reading states this exposure combination is proper for the lighting of the scene. Then, just before you can trip the shutter, a large dark cloud goes by and covers your intended subject matter in shade. If you were to take the photograph at that instant, without altering the exposure settings for the change of ambient light, the resulting photograph would come back underexposed. The exposure setting was for a fully sunlit scene, but you used that exposure combination for a scene in shade, resulting in underexposure.

Therefore, the changing ambient light is a variable in your exposure calculations. You have minimal control over the ambient lighting and usually vary the other camera exposure variables to ensure you will have a proper exposure. You must, however, be constantly mindful of the ambient light's ability to change while you are busy trying to calculate the proper exposure settings.

You can normally alter the ambient lighting in two ways. As stated previously, you can add electronic flash to the lighting of the scene. Chapter "Electronic Flash" discusses electronic flash techniques. A second method by which you can alter the ambient lighting of the scene is by intentionally creating a shadow over a part of the scene. For instance, if you are photographing an item of evidence early in the morning or late afternoon, the low angle of the sun may create distracting shadows on the evidence. As mentioned in chapter "Crime Scene Photography," sometimes distracting shadows can be eliminated. Merely block the sun and expose for the evidence within a shadow. The evidence now will not look underexposed; it will look properly exposed, but without shadows (see Fig. 4.21).

This ability to block the sun to create a shady area over an item of evidence or a small area of the crime scene obviously will not work on larger areas. Having some lighting control over smaller areas of the crime scene, however, is an important capability.

THE COLOR OF AMBIENT/EXISTING LIGHT

Although you do not normally see the different effects that various lighting sources will have on their surroundings, daylight color film and digital sensors can record these different effects. When the task is to faithfully capture colors within a crime scene, you should know only two choices of lighting can be used when using film. Choices with digital cameras will be explained shortly.

RULE OF THUMB 4.4

For accurate color capture, only use either midday sunlight, which is approximately the bright yellow sunlight from 10 am to about 3 pm, use an electronic flash, or ensure the digital white balance setting is for your current lighting.

Both of these light sources, the sun and electronic flash, will ensure that various colors within the crime scene were accurately captured on a digital sensor. Other lighting conditions will result in various tints to the scene and the evidence within the scene if the **White Balance** is set incorrectly.



FIGURE 4.21
Shadow pattern over scissors; block the sun and expose for the shade.

Shade, Cloudy, Twilight

If the crime scene and the evidence are not lit with the bright midday sun, the color of the light shifts toward blue. Lacking the bright yellow of the sun, you may still have sufficient light intensity for a proper exposure with small apertures, ensuring an adequate depth of field. Although the amount of light might be adequate, you also have to be concerned with the color of the lighting. A bluish tint may ruin an otherwise fine photograph. Worse yet, it may make a photograph unusable in court because the image is no longer a fair and accurate representation of the scene as you saw it. Minor lighting tints, however, can usually be corrected with digital software, if captured by a digital camera.

The Fig. 4.22A is not so much underexposed as it is tinted blue because the image was exposed in a well-shaded area. The use of an electronic flash for the Fig. 4.22B captures the true color of the tire track on cement.

Sunrise, Sunset

Early in the morning or late in the afternoon, it is frequently easy to see that the sun is tinted a distinct orange/red rather than its normal yellow color. This change to the color of the predominant light source will certainly be recorded on film. Unfortunately, the eye–brain combination is such an extraordinary compensator for minor deviations in lighting that you normally do not notice this color shift. As you gaze around, things you know to be white are still seen as white, even though an obvious tint is present. Film, however, will record this change. If color accuracy is critical to a particular image, it is essential to use electronic flash to "correct" for the tint produced by the sun at such low angles. It is always best to capture the image correctly, even if it can later be "corrected" if an improper tint should arise.

The images in Fig. 4.23 of a car taken in the late afternoon demonstrate this effect. The first image by itself may not look too objectionable until the color-corrected image is shown adjacent to it. If you are not photographing with midday sunlight, electronic flash is your only other option if you wish to capture colors accurately. Despite the fact that such tints may be corrected with digital software, this text's goal is to make you a better photographer, not a better digital image processor.

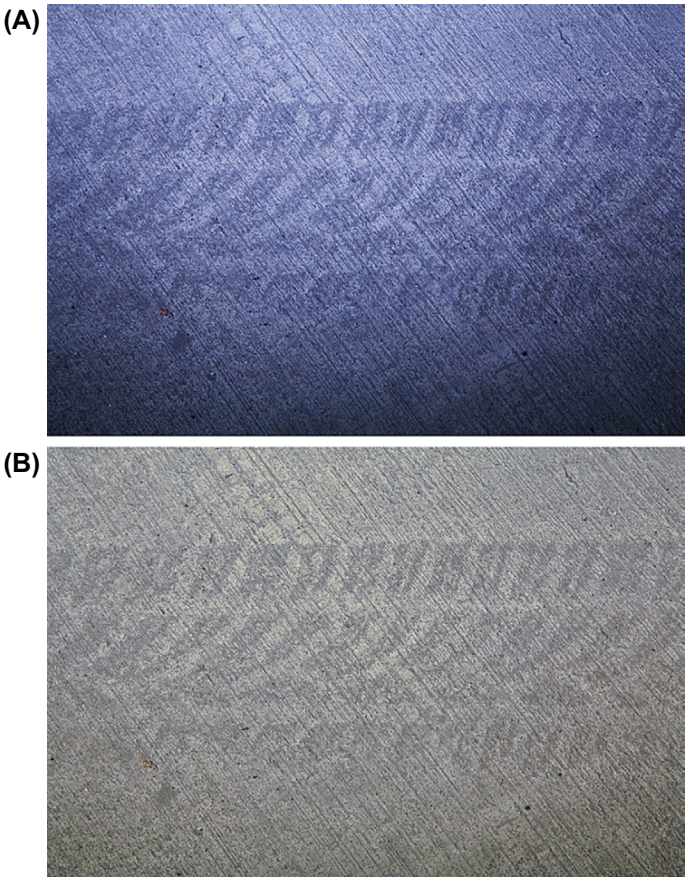


FIGURE 4.22
(A) A blue tint caused by a shady scene with no direct sunlight. (B) The tint avoided, either by selecting a "shade" white balance setting; or using flash.

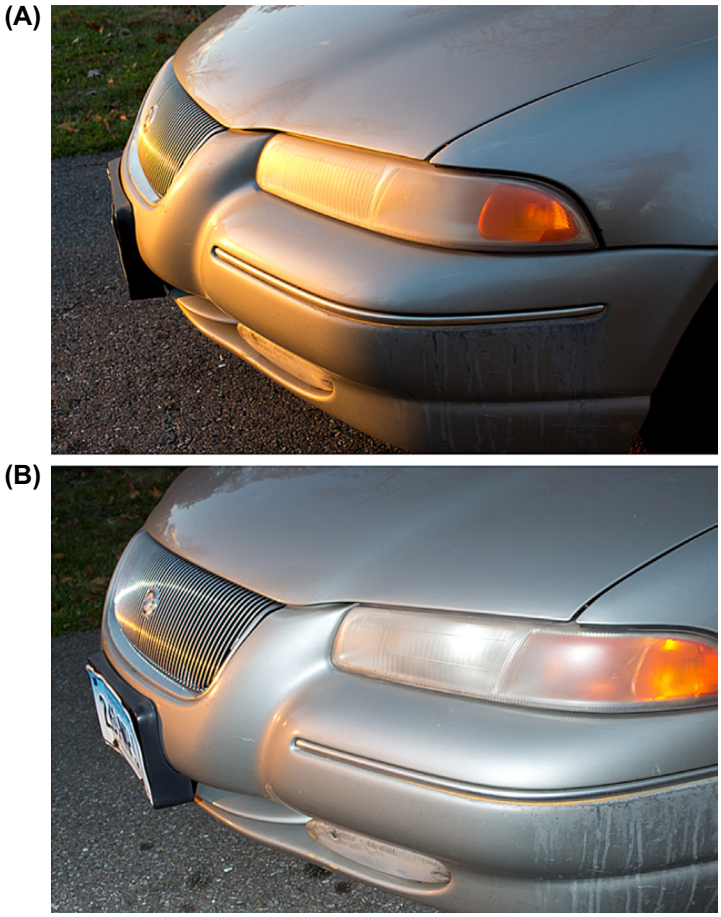


FIGURE 4.23
(A) Early morning sun causing a yellowing tint. (B) Flash eliminating the tint.
Courtesy of Dale Rio, GWU MS student.



FIGURE 4.24
Taken with flash, tungsten light, and fluorescent light.
Courtesy of S. Dickson and B. Pridgen, GWU MFS students.

Tungsten

When you are taking pictures indoors, the predominant light source is frequently tungsten light, or ordinary household light bulbs. If electronic flash is not used indoors, tungsten lighting can produce a yellowish/amber tint (see the center images of Figs. 4.24 and 4.25). Whenever indoors, electronic flash must be used to ensure proper colors are captured. Again, the ambient lighting may be sufficiently intense for a proper exposure, but is it the right color of light? No.



FIGURE 4.25
Taken with flash, tungsten light, and fluorescent light.

Fluorescent

Fluorescent lighting is another indoor lighting variation to tungsten lighting. Many businesses and offices are lit predominantly with this type of lighting. Although it looks like white light to the eye, many types of fluorescent tubes lack much of the red component of white light. Without one part of the normal white light color spectrum, the opposite of the color that is absent will tend to become the predominant color. Opposite red on the standard color wheel is green. If fluorescent lighting is used to expose the image, a green tint is the usual result. Some fluorescent lights will produce an amber tint. Fluorescent lighting does not produce truly accurate colors on a digital sensor without the white balance being set for fluorescent light or if a flash is used.

See the bottom images of Figs. 4.24 and 4.25.

Again, color corrections can be made with digital software. Nevertheless, it is better to accurately capture the correct color in the first place. Having to make color corrections implies that the proper color was not originally captured. Although it is comforting to know slight errors can be corrected later, they are still corrections.

Outdoor Lighting

When midday sun is not available when capturing photographs outdoors, some scenes can result in a various tints, sometimes with a tendency toward a yellowish or orange tint. This included early mornings and late afternoons, as we have seen.

The sun can also make some black-colored clothing look brownish. In Fig. 4.26, a jacket looking brown because of the street lighting is actually black when photographed with a flash. In a robbery case, witnesses to a convenience store being robbed described a suspect running from the store as wearing a brown jacket with a shark and hockey stick (San Jose Sharks) logo on it. The police caught a suspect running from the scene with the money, and the same jacket with a shark and hockey stick logo was being worn, except the jacket was black. To prepare for court, and to help convince the jury the police caught the right robber, they photographed the jacket in the lighting outside the store which was robbed, and with an electronic flash, and then merged the two images together to show the jury the same jacket can seem to be brown in some lighting despite the fact it is really black (Fig. 4.27).

Street lighting can also change the perceived colors of vehicles. See Figs. 4.28–4.30. The correct color of each pair of cars is the one photographed with a flash. The next time you are given a description of a vehicle used in a crime, keep these images in mind, and have a little flexibility when you decide which vehicle to stop because of its color.



FIGURE 4.26
A black jacket under different lighting.
Courtesy of S. Keppel, GWU MFS student.



FIGURE 4.27
A black jacket under different lighting.



FIGURE 4.28
Tint eliminated with flash.
Courtesy of J. Veltri, GWU MFS student.



FIGURE 4.29
Tint eliminated with flash.
Courtesy of K. Martin, GWU MFS student.



FIGURE 4.30
Tint eliminated with flash.
Courtesy of S. Keppel, GWU MFS student.

At times, an image can also have a distinct blue tint. Several lighting conditions produced these blue tints, and most are related to a lack of direct sunlight. If the day was overcast, bluish tints can be noticed. If the area captured in the image was in "open shade," the result is frequently a bluish tint. "Open shade" means that the sun is currently being blocked and cannot directly strike the area being photographed. However, if you were to look upward, the bright blue sky was directly lighting the scene (Fig. 4.31). To eliminate the blue tints, photographers can now make digital white balance adjustments, ensuring the white balance setting is appropriate for the lighting.

Digital White Balance

Digital cameras will render the proper colors of the scene if exposed with midday sunlight or electronic flash. However, a photographer using a digital camera has more control over the accuracy of the final colors appearing in the image. When objectionable tints may result from the wrong type of lighting, the photographer using a digital camera can set the white balance on the digital camera so that it is appropriate for the light in which the image is being taken.

You are likely familiar with the concept of white balance, because when camcorders first became popular, white balance was one of their features.

Digital cameras allow the photographer to set the appropriate white balance for the ambient light. Fig. 4.32 shows a typical set of choices a digital camera menu will offer the user.

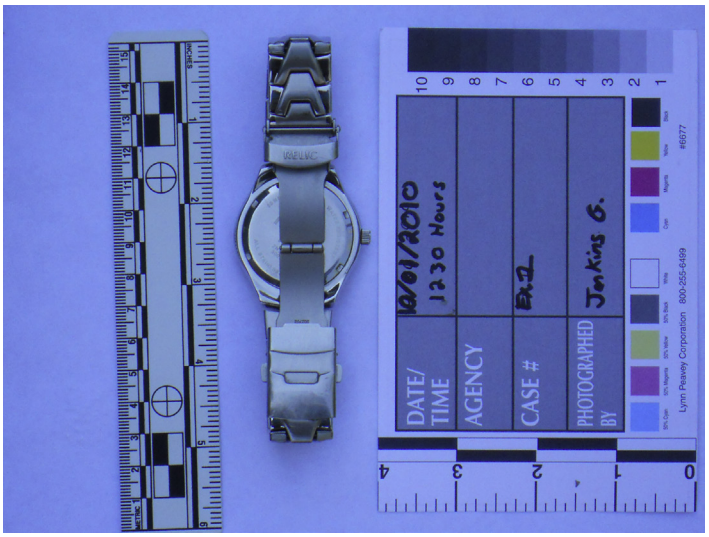


FIGURE 4.31
A blue tint from shade.
Courtesy of G. Jenkins, GWU MFS student.

Display	Mode
AWB	Auto
☀	Daylight
⌂	Shade
☁	Cloudy, twilight, sunset
☀	Tungsten
▭	White fluorescent light
ϟ	Flash

FIGURE 4.32
White balance setting options.

Digital cameras also have the choice of automatic white balance. This setting will provide for proper colors if, and only if, some object is within the scene that is white, or very nearly white. The auto white balance setting will attempt to ensure that those white objects in the scene are, in fact, white. If no white objects are within the scene, the best option is to set the white balance setting for the precise type of light at the scene. Doing so will ensure the original image is properly colored and eliminate the necessity to make color corrections in a postprocessing software program like Photoshop.

When capturing the accuracy of the colors within the image is critical, what are your choices?

- Capture the image lit with the midday sun.
- Use electronic flash.
- Set the digital white balance for the lighting conditions affecting the scene.

So, you have used one of the above to ensure you captured the colors of the scene accurately. The next obvious question is how do you convince the jury that the image you are presenting in court was **printed** with accurate colors? That is a different issue with a different solution. Since it is true that the colors of an image can be altered during the processing of the digital file into a print which can be taken to court, how is it possible to prove color changes were not made? The answer is actually quite simple. When color accuracy is paramount, somewhere in the composition you should add a color scale. We have already shown one to you. The fully labeled scale which was previously suggested for documenting close-ups has a color scale on it (Fig. 4.33A). Fill this labeled scale out when accurate colors are crucial, include it somewhere in your image, and turn it in with your images. When the color print is made, it will look just like the color scale on the fully labeled scale, ensuring all the other colors are accurate as well. Some might use the gray scale and color patches from the Kodak Professional Photoguide instead (Fig. 4.33B). There is no mandatory color scale which must be used. Just make sure to include some variation of a color scale in your composition when the accuracy of colors is critical.

Digital Sensors Cannot Capture All the Scene's Details in Extreme Lighting Conditions

A digital sensor's ability to capture details in a scene with extreme lighting conditions is limited. The most frequently encountered extreme lighting condition is found in a scene lit with strong midday sunlight. Usually, dark shadows are also present with this type of lighting. The camera's exposure settings necessary to properly expose objects in the sunlight will be vastly different than the camera's exposure settings necessary to properly expose objects in the deepest shadows. If it were necessary for the crime scene photographer to capture two items of evidence adjacent to each other, but one item of evidence was directly lit by the midday sun and the second item of evidence was in a deep shadow, the digital sensor may not be able to properly expose both items of evidence at the same time.

Of course, if the photographer were able to take one image of the evidence lit just by the midday sun, that would be easy. If the photographer could recompose on just the second item of evidence in the deep shade, that would also be an easy exposure. In both situations, only one lighting extreme would be present. But if the photographer thought it necessary to include both items of evidence in only one photograph, because he or she wanted to show the distance relationship between the two items of evidence, for instance, then this exposure problem must be solved.

One of the needs for **High Dynamic Range (HDR)** imaging is that the digital sensor has an inherent inability to properly expose items within wide extremes of light.

For the sake of discussion, presume for a moment that the item in the sunlit area required an exposure combination of 100 ISO film, f/22, and 1/60th of a second shutter speed. If those were the exposure settings used, the item in the sunlight would be perfectly exposed.

Also presume the item in deep shade required an exposure combination of 100 ISO film, f/4, and 1/60th of a second shutter speed. If those were the exposure settings used, the item in the deep shade would be perfectly exposed.

If the first exposure combination were used for both items at the same time, the item in deep shade would be 5 stops underexposed and would be so dark that it would probably not be seen at all. If the second exposure combination were used for both items at the same time, the item in bright sunlight would be 5 stops overexposed and would be so burned out that it would probably not be seen at all. Fig. 4.34A, provides an example, although not as extreme as some scenes can be. Had a critical item of evidence, a weapon, for instance, been located to the rear of the vehicle's front right tire but on the asphalt, it would be visible in this image at the expense of badly overexposed sunlit areas of the scene. The exposure was set for the shady area of this scene; notice the grass by the curb is properly exposed.

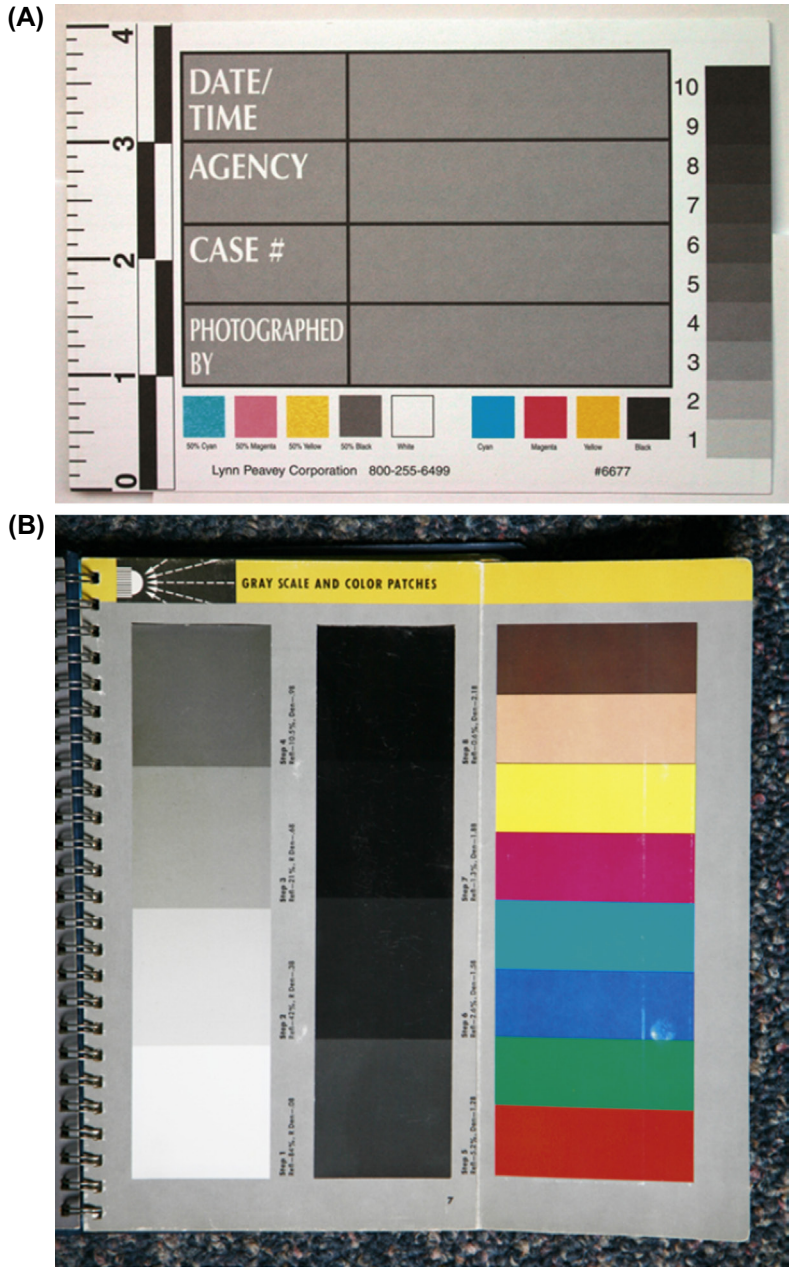


FIGURE 4.33
(A) Photo identifier with a color chart. (B) Gray scale and color panels, Kodak Professional Photoguide.

In Fig. 4.34B, where the exposure was set to properly expose the sun lit areas of the scene, the hood and grass at the lower left corner, the same weapon would be completely hidden in shadow.

How can one photograph both of these areas, with the same composition as seen, and have both properly exposed? The first possible solution that frequently comes to mind is to consider an exposure setting that will be an exposure compromise and, with any luck, properly expose both items at the same time. The f/stop midway between f/22 and f/4 is f/9.5. That would be $2^1/_2$ f/stops wider than f/22, and $2^1/_2$ f/stops smaller than f/4. Is this really an adequate compromise? No! If the item in direct sunlight really needed an f/22 for a proper exposure, using an f/9.5 would make it $2^1/_2$ stops overexposed. If the item in deep shade really needed an f/4 for a proper exposure, using an f/9.5 would make it $2^1/_2$ stops underexposed. Both would be improperly exposed in the same photograph. The use of a middle-ground f/stop is not the solution.

Solutions exist, however. One is to use a technique called **Fill-in Flash**. This technique will be discussed at length in chapter "Electronic Flash." It should be mentioned here that crime scene photographers frequently use fill-in flash during



FIGURE 4.34
(A) Exposed for the shady area. (B) Exposed for the sunny area.
Courtesy of M. Ward, GWU MFS student.

the daytime. It is the primary method to "even" the lighting extremes when bright areas of a scene and dark shadows are present in the same area. A second solution to this exposure problem is to first realize that the exposure problem does exist and then to make exposure corrections when postprocessing a digital image with software programs like Photoshop. However, it is best to capture the image with a correct exposure originally, rather than to rely on corrections later.

The term high dynamic range in digital photography is similar to the term "**Exposure Latitude**" in film photography. HDR refers to the exposure extremes digital pixels on the digital sensor can detect and record. Digital cameras that can detect and capture large amounts of shadow detail and large amounts of highlight detail at the same time are referred to as having a "HDR." When there are more data than the camera's sensor can capture, either in the shadow or highlight area, it is said that the resulting image captured has "clipped highlights" or "clipped shadows." This can be confirmed by looking at the histogram for the image in question. If details are "clipped" in either the highlights or shadows areas, the histogram will show this by a tall line at either end of the histogram. See Fig. 4.35.

In the top histogram, there is a thin line on the extreme right side of the histogram, representing very light toned details. In the bottom histogram, there is a thin line on the extreme left side of the histogram, representing very dark toned details. Both of these lines indicate there were data present when the image was captured which the digital sensor could not distinguish, and all these data are now represented as being either totally black or totally white. In other words, these data are lost from view!

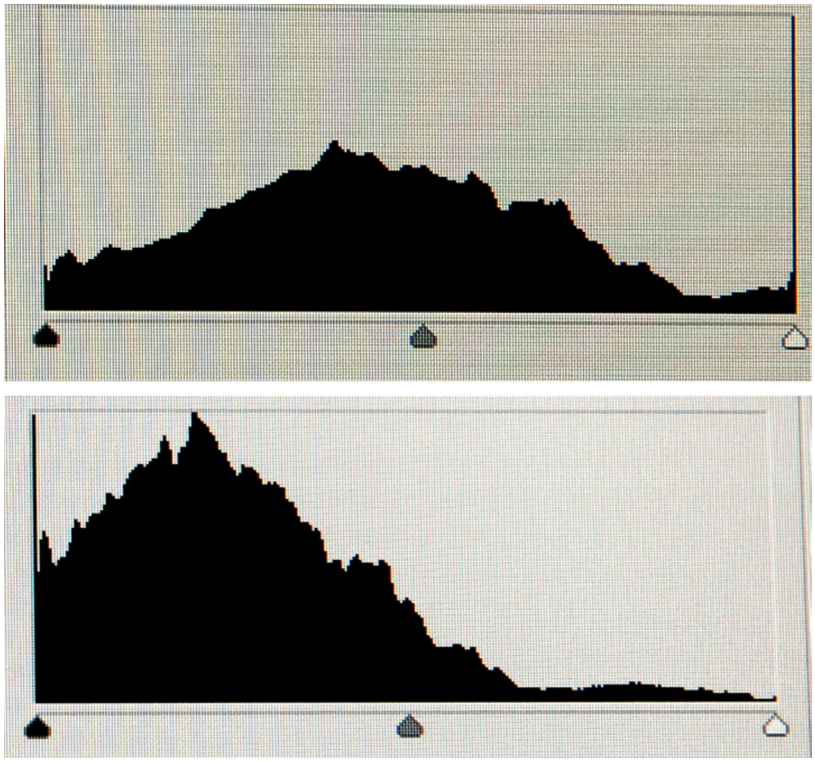


FIGURE 4.35
Histograms showing "clipping."

Some digital SLR cameras have better HDRs than other digital SLR cameras. Digital SLR cameras, however, still have limits to the extent they can capture all the details of a scene with both very bright areas and very dark areas.

There are software programs designed to provide "fixes" to this "clipping" tendency. These programs can take bracketed images, a series of at least three exposures at 0, +1, and –1, and combine them into one image. Details which were originally too dark to see in the proper exposure (0) can be seen in the +1 exposure. And, details which were originally too overexposed to see in the proper exposure (0) can be seen in the –1 exposure. In just one HDR image, the details in all three images will be able to be seen at the same time.

This has previously only been able to be done by postprocessing images with software programs like Photomatix Pro and Adobe Photoshop. However, at the writing of this third edition, at least two camera giants, Nikon and Canon, now feature digital SLR cameras with HDR capabilities. Canon calls it "built-in HDR" and Nikon calls their version "Active D-Lighting." Both allow the photographer to select a series of bracketed images and "merge" them into one HDR image with the visible details of all the images. All this can be done in-camera.

An updated section on HDR photography is featured in the Appendix.

BEST TO UNDEREXPOSE DIGITAL EXPOSURES

However, the digital sensors available today still cannot capture, in one unprocessed image, all the details present in a scene featuring both bright sun lit areas and areas in deep shadow.

Detail in a very overexposed digital image usually cannot be salvaged. Nevertheless, there is very good news for today's digital camera users. Photographers using digital cameras now have a tremendous ability to pull detail out of underexposures. This can be a new Rule of Thumb.

RULE OF THUMB 4.5

If an exposure error is unavoidable, it is better to underexpose digital images a bit. More detail can be obtained from a digital underexposure than a digital overexposure.



FIGURE 4.36
Film push processing results.



FIGURE 4.37
Digital processing of underexposures.

Once, when a photographer had access to a professional film darkroom, the most which one could expect them to recover from intentionally underexposed film, by using the state-of-the-art "push" processing techniques, were details that were 3 stops underexposed. See Fig. 4.36. Push processing involved the processing of the film for extended durations in the film chemistry. The result was not very pretty, but detail which may help an investigation could be obtained. In Fig. 4.36, although the face cannot be recognized any longer in the 3-stop "push," the license plate numbers can still be read.

With just basic Photoshop processing, it is relatively easy to find usable details in grossly underexposed digital images, and this author does not consider himself a Photoshop "expert." With film, and a professional film processing lab, a 3-stop underexposure could yield just some usable detail. Now, the world seems to have gone completely digital. With just basic Photoshop skills, this author has pulled usable detail out of images which were 9-stops underexposed. See Fig. 4.37.

The bottom line is that being just a bit underexposed is not much of a problem with today's digital photography.

GLOBALLY INCREASING OR DECREASING EXPOSURES

Within Photoshop, exposure corrections can be applied to the entire image at the same time. There are a variety of contrast changes that can be applied to a digital image. The entire print would show the results of these uniform exposure changes. There are a variety of contrast changes that can be applied to a digital image. This text has two chapters on digital image processing with more specific details. More or less light can be added to the entire image as desired.

BURNING AND DODGING SELECTED AREAS OF AN IMAGE

At times, the entire image may not suffer from a uniform exposure problem. Only isolated areas of the image may be improperly exposed. In these cases, it is possible to improve the exposure of just these small areas. These areas of the print requiring to be lightened or darkened a bit can receive those adjustments required.

However, it is important to know that the terminology to lighten and darken selected areas of an image, in a digital environment, is based on the terminology once used when working with film and negatives. And, because negatives were used, some find the terminology of **"Burning"** and **"Dodging"** confusing. This is because, with negatives, lights and darks became reversed.

In the wet-chemistry darkroom of the past, light was projected through a film negative and allowed to strike white photographic paper. The photographic paper was chemically treated to **darken** when light struck it. Normally, we think that when light strikes an object, the light makes the object brighter. With photographic paper, it is just the opposite; when light strikes it, it darkens. Normally, we think that when light is withheld from striking an object, it will be dark or underexposed. With photographic paper, it is just the opposite because it is already white. If you withhold light from getting to it, it will remain white; withholding light from photographic paper results in areas which are lighter or brighter.

First, with film, a properly exposed print was made on the white photographic paper. If some small areas of the print were considered a bit **underexposed**, it was because the light-sensitive photographic paper received **too much** light. Remember, light makes the white photographic paper darker. The trick was to make a new print, but during that exposure, one would try to "dodge" the areas which had first been too dark. "Dodging" meant attempting to insert an object between the negative and the photographic paper in the areas it was felt were underexposed. Frequently, the dodging tool was a round opaque disc on a stick. When put between the negative and photographic paper, the disc would block some of the light coming through the negative, resulting in a lighter area on the paper. The processor would have to keep the disc constantly moving during the exposure; otherwise a light area in the shape of a circle would appear on the print.

"Burning" with film processing meant your original print had small areas which were considered to be overexposed/too bright. Allowing more light to strike the photographic paper in those areas would darken those areas to the point they were more properly exposed. Paper or cardboard would be put between the negative and the photographic paper; only this time, the cardboard was shaped to block light from hitting all the other areas of the print which were already properly exposed, and corners or holes were cut out to allow additional light to go past the cardboard obstruction just in the areas needing to be darkened. Again, the cardboard obstruction was kept in constant motion to avoid the obstruction edges from being distinct on the print.

The bottom line, with film:

- Burning (adding light to photographic paper) darkens an image.
- Dodging (withholding light from reaching the photographic paper) lightens the image.

It is the same with digital processing.

- To correct an underexposed area of a digital image, use the Dodge tool,
- To correct an overexposed area of a digital image, use the Burn tool.

This ability to correct improperly exposed images should not make you lax when the original exposure is determined in the field. The most carefully exposed digital image will yield the best print. It is better to be able to determine the proper exposure at the crime scene than to be able to correct mistakes with digital software. Most would agree that the ideal situation is to become a better photographer, and determine the correct exposure when the image is originally captured, rather than become a better technician, able to later correct the exposure mistakes made at the crime scene. Knowing corrections can easily be made is, however, enormously comforting to most.

SHUTTER SPEED AS MOTION CONTROL

Motion Control to Eliminate Blur

Generally, three types of movement can be controlled by an appropriate shutter speed:

1. Photographer body movement
2. Subject motion
3. Camera movement

Photographer Body Movement

If the camera is moved during an exposure, the photograph can be blurred. One type of camera movement can be a result of simply holding the camera improperly. The camera needs to be braced properly to eliminate as much camera movement as possible. Of course, you will be holding the camera with two hands. The right hand holds the right side of the camera body, with the index finger ready to depress the shutter button. The left hand normally cradles the bottom of the camera, with the left thumb and index finger available to either rotate the focus ring or change focal lengths on a zoom lens.

Frequently, three other methods can be used to steady the camera. Rather than having your elbows extended from your body, they need to be tucked in close to your chest. They act like a bipod to help steady the camera. In addition, you usually steady the camera somewhat by bringing it in close to your face and making contact with your brow or forehead. Although some are not keen on this, frequently the camera is also making contact with your nose. Many are not consciously aware this is done until they notice nose oils on the back of the camera or LED screen. The more methods used to steady the camera the better.

A proper choice of shutter speeds can eliminate the blur that can still result from hand-holding the camera. As steady as you might think you can hand-hold a camera with the preceding techniques, you cannot eliminate the movement of your heartbeat. You may be able to hold your breath, but you cannot stop your heart from beating during the exposure. Believe it or not, the beat of your heart is enough to blur a photograph. Fortunately, you can compensate for this movement by the proper selection of a shutter speed, which forms another Rule of Thumb.

RULE OF THUMB 4.6

To eliminate possible blur from hand-holding the camera, use the shutter speed that is the closest to the focal length of the lens on the camera, inverted into a fraction.

For instance, if the camera had the standard 50 mm lens mounted on it, 50 inverted into a fraction would be 1/50th. Therefore, using the shutter speed that is nearest to 1/50th of a second, or faster, would effectively eliminate the possibility of blur from hand-holding a camera with a 50 mm lens mounted on it. The closest shutter speed to 1/50th is usually 1/60th. Therefore, a shutter speed of 1/60th effectively eliminates the blur that can result from hand-holding a camera with a 50 mm lens on it.

Wide-angle lenses, however, do not follow this rule; 1/60th is normally the **slowest** shutter speed recommended when hand-holding a 35 mm SLR camera, even with a wide-angle lens on it. Some professional photographers brag about being able to hand-hold a 35 mm camera while using a 1/30th shutter speed. Do not be swayed by their bravado. Adhere to the Rule of Thumb. Crime scene photography is too important to risk blur because of an ego problem. Therefore, resist the urge to use a 1/30 shutter speed if you are using a 28 mm lens on your camera.

Telephoto lenses, however, do follow the rule.

Consider the situation in which you will be hand-holding a camera with a zoom lens set to an 80 mm focal length; 80 inverted into a fraction would be 1/80th. The closest shutter speed to that is 1/90th, which is $^1/_2$ stop between 1/60th and 1/125. If your camera does not have shutter speeds in $^1/_2$-stop increments, you would have to use 1/125 as the shutter speed to hand-hold a camera with an 80 mm lens on it.

Hand-holding a 100 mm lens requires a shutter speed of 1/100, if your camera has it; 1/125 if your camera does not have the option of a 1/100.

If you are using a 300 mm lens on the camera, you must select a shutter speed of 1/300th, or faster, to avoid blur from hand-holding the camera with that lens on it. Some cameras have a 1/350 halfway between a 1/250 and 1/500. If not, then you would have to use the 1/500th shutter speed.

Hand-holding a 500 mm lens would then require a shutter speed of 1/500th.

If, for some reason, you cannot use the focal length of the lens converted into a fraction as your shutter speed, the other alternative to hand-holding the camera is to mount the camera on a tripod. With the camera mounted on a tripod, movement of the camera is virtually eliminated, and thus slow shutter speeds can be used without blurring a photograph. With the camera mounted on a tripod, some camera movement may still occur when the shutter button is depressed. If you want to avoid this, one of two solutions is usually recommended when the camera is on a tripod.

First, use a remote shutter release cable, as mentioned previously. A remote shutter release cable enables you to trip the shutter by depressing the button/plunger at the end of the cable. This mitigates the shock of depressing the shutter button itself, and any associated vibration is absorbed in the length of the flexible cable. No camera movement means no blurred images from camera shake.

Many modern cameras also have a delayed shutter release, usually with a choice of delay times. Frequently, a 10-s shutter delay is set on the camera. In this case, depressing the shutter button directly does not adversely affect the image. If any camera movement was associated with the depression of the shutter button, that movement is dissipated during the 10-s lag time between the depression of the shutter button and the shutter actually tripping 10 s later. Many cameras also have a 2-s and 5-s shutter lag time option.

Whenever a camera is mounted on a tripod, it is recommended that one of these features be used. Directly depressing the shutter button can result in a blurred image, even if the camera is mounted on a tripod.

Subject Motion

At times, unavoidable motion will be present within the camera's field of view, and it is essential to be able to recognize the people or vehicles in the resulting photographs. Such is the case with surveillance photographs, when the subject(s) of the surveillance will be moving. It also becomes important if the assignment is to photograph a battered child, who will not sit still at your request. Usually, at crime scenes and accident scenes, the scene and evidence within the scene are static, and subject movement is not an issue. But, when it is essential to freeze the motion of anything moving within the scene, knowing how to solve this problem is critical. At an accident scene, for example, victims may be in the process of being removed from the scene by medical personnel. As they are being wheeled away from the scene, you may want to capture an image or two of their apparent injuries. If their treatment is critical, it would be improper to delay their removal from the scene, so you must "grab the shot" while you walk alongside the moving gurney. With the proper shutter speeds selected, even these kinds of motion can be stopped or frozen.

Consider these recommendations for motion control:

Normally,

- 1/125th will "freeze" a walker, enabling the face to be recognized.
- 1/250th will "freeze" a jogger, or someone running, or jumping.
- 1/500th will "freeze" a bicyclist or a slow-moving vehicle (up to about 30 mph).
- 1/1000th will "freeze" a vehicle going up to 60 mph.
- 1/2000th will "freeze" an airplane powered by propellers (see Fig. 4.38).

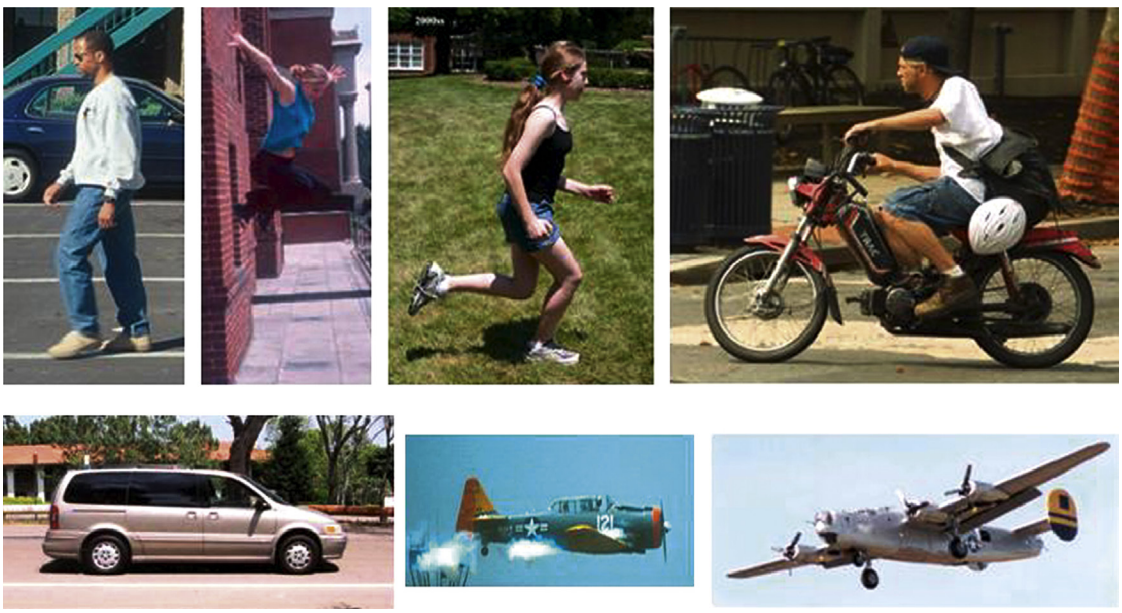


FIGURE 4.38
Shutter speeds "freezing" motion.

Of course, fast shutter speeds can freeze motion. Although this point will become clearer in chapter "Electronic Flash," the use of electronic flash can also freeze subject movement. The upset battered child, bouncing around on a mother's lap, can effectively be frozen in place with electronic flash. Fast flash durations are the reason, and this facet of electronic flash will be covered in the chapter "Electronic Flash."

Another photographic technique can aid in the "freezing" of motion. That is panning. "Panning" is the term applied to the photographer's tracking the subject's movement with the camera: in other words, moving the camera to keep the subject in the field of view while the subject is moving. Sports photographers use this technique in their attempt to capture dynamic motion, while at the same time being able to recognize the athlete diving for a touchdown, arcing over a high bar, or stretching toward the finish line.

This technique is less successful when used for law enforcement purposes. Although this technique will generally ensure that the moving subject is recognizable, because the camera is moving during the exposure, the background will also be blurred. If it is necessary to recognize the subject and to recognize the building he or she is entering or exiting from, panning is less successful.

When a photographer is doing moving surveillance, camera motion is unavoidable. Consider the scenario when a suspect will be meeting with known felons in an area also known for its high crime rate. It would be possible to photograph both subjects and the scene with the photographer in the back seat of a vehicle as it drove by. In this case, it would be necessary to have selected a shutter speed sufficient to freeze the motion of the car and the camera within the car.

Using Slow Shutter Speeds to Eliminate Rain and Snow

Slow shutter speeds emphasize the blur caused by movement within the field of view. At crime scenes and accident scenes, the last thing you normally want is blurred images. Blur can ruin a photograph, and it can make the photograph ultimately inadmissible in court as evidence. However, there is a common circumstance in which a slow shutter speed is actually a benefit to law enforcement photography.

When a photographer is photographing a scene in bad weather, it is possible to "freeze" the raindrops or snowflakes with appropriately fast shutter speeds or with the use of electronic flash. This would certainly document the fact that it was, indeed, raining or snowing at the time photographs were taken. However, these same raindrops or snowflakes would make it difficult or impossible to see the scene very clearly, and the evidence within the scene may also be obscured. If a slower shutter speed is used, the "frozen" raindrops and snowflakes will be captured as blurs. These blurs also effectively mask the scene and the evidence within the scene.

With a shutter speed that is slow enough, the raindrops or snowflakes can be intentionally blurred so much that they cease to be captured on the sensor. During a long exposure, what is consistently in the field of view, in the same location, during the entire exposure will be captured on the sensor. But individual raindrops or snowflakes will not be in the field of view long enough to be recorded by the sensor, so the result is a scene without the rain or snow.

In these situations, it is recommended that at least one image be taken that does document the fact that it was raining or snowing at the time. The snow, for instance, may be a contributing cause of an accident. Or, it may affect a witness's ability to see what he or she is reporting to have seen. Crime scene photographers should never allow their photography to be accused of misrepresenting the scene. However, once the fact that it was raining or snowing has been documented, it is no longer necessary to capture the rain and the snow in every remaining photograph. From then on, it is just necessary to document the scene and the evidence within the scene, and the raindrops and snowflakes can then be considered some sort of visual contaminant between the camera and the scene.

For instance, if a tree branch were obscuring the scene from the point of view of one witness, it would certainly be necessary to take a photograph from the witness's point of view, with the tree branch blocking the view. Thereafter, to document the scene and the evidence, the photographer would choose viewpoints avoiding the tree branch.

Some jurisdictions have large tarps or tents available to cover outdoor crime scenes during inclement weather. Just as it is understandable to protect the crime scene from the deterioration that can be caused by bad weather, being able to photograph the crime scene without the bad weather interfering with an unobstructed view of the scene and the evidence within it is a distinct advantage.

Practical experiments have shown that shutter speeds in the 2–3 s range normally effectively eliminate rain and snow from the image. Such slow shutter speeds obviously require the use of a tripod; otherwise, the scenes themselves will be blurred as well. These slow shutter speeds also let in an enormous amount of light. It can be quite bright even while it is raining or snowing. Sometimes, even when using a slow ISO, like 100, and using the smallest aperture the lens has, like an f/22, the camera's exposure meter may still indicate overexposure if the image is captured without any further adjustments.

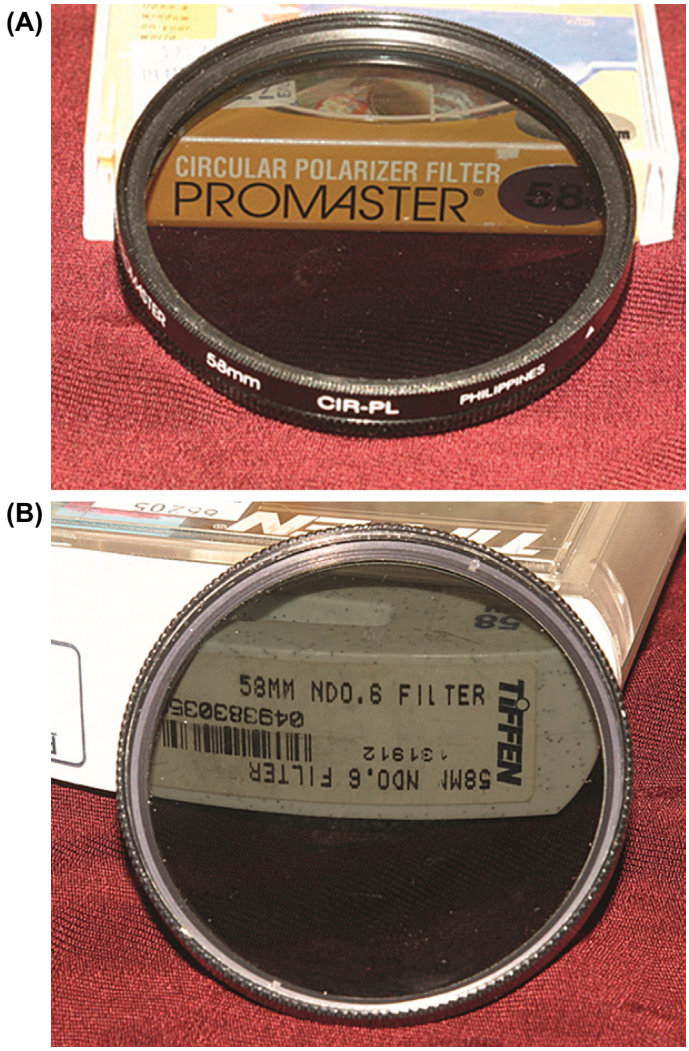


FIGURE 4.39
(A) A polarizer filter reducing the light behind the filter. (B) A 2/stop, 0.6, **Neutral Density Filter** reducing the light behind the filter.

How can you avoid an overexposure in these situations? One answer is to use "sunglasses" over the lens, just as you would personally use sunglasses at any bright outdoor scene. For the camera lens, these "sunglasses" are filters. Two types of filters may help in this situation.

One type of filter that can block some of the light coming in through the lens is a **neutral density (ND) filter** (see Fig. 4.39B).

Such filters are usually available in three increments. ND filters typically come with the ability to block precisely 1 stop of light, 2 stops of light, or 3 stops of light. Depending on the level of overexposure present at the scene, the appropriate ND filter can be selected as required. ND filters do not affect any colors within the scene; they merely reduce the overall lighting in precise increments.

Notice how the 2-stop ND filter in Fig. 4.39 reduces the overexposure behind the lens. A ND filter blocking 1 stop of light is usually designated by either a 0.3 or a 2×; 2 stops of light reduction are designated by 0.6 or 4×; 3 stops of light reduction are designated by 0.9 or 8×, depending on filter manufacturer.

Another filter that may be used in similar situations is the **Polarizer Filter**. The primary use of a polarizer filter is to eliminate reflections from windows and water and to eliminate glare that may hide the actual colors present at the scene (see Fig. 4.39A). These aspects will be covered in a subsequent section on filters. Polarizer filters, however, also uniformly reduce the light coming through the lens. Depending on the degree of rotation of the polarizer filter, the degree of light eliminated by the filter can vary from 1.3 stops to 2 stops of light. Therefore, if a rainy or snowy scene is currently overexposed by 1.3–2 stops, the polarizer will work nicely to provide a proper exposure.



FIGURE 4.40
(A) Original snowy scene. (B) Snow eliminated with 2-s shutter speed.
Courtesy of Melanie Towers, GWU MFS student.

Therefore, if using a 100 ISO equivalent with the camera's smallest f/stop and a 2-s shutter speed still results in an overexposure, adding an ND filter or polarizer filter to the lens may reduce the light striking the film sufficiently to provide a proper exposure. This exposure combination has the additional benefit of eliminating the snow as it is falling (see Fig. 4.40).

If your digital camera has an ISO equivalent of 50, switching to this setting would also help avoid the overexposure. Many times, this author still forgets that this exposure control is available, since during his career in the field, 100 ISO film was the slowest ISO option available.

RECIPROCAL EXPOSURES

The purpose of Fig. 4.41A is to explain why a variety of f/stop and shutter speed combinations result in the exact same exposure. Changing one of the exposure variables is permissible if the other exposure variable is also changed to balance the first adjustment. Increasing one exposure variable by 1 stop is balanced by decreasing the other exposure variable by 1 stop. Increasing one exposure variable by 2 stops is balanced by decreasing the other exposure variable by 2 stops.

Fig. 4.41A is designed to be copied from the text and cut vertically down the middle through the middle hash mark.

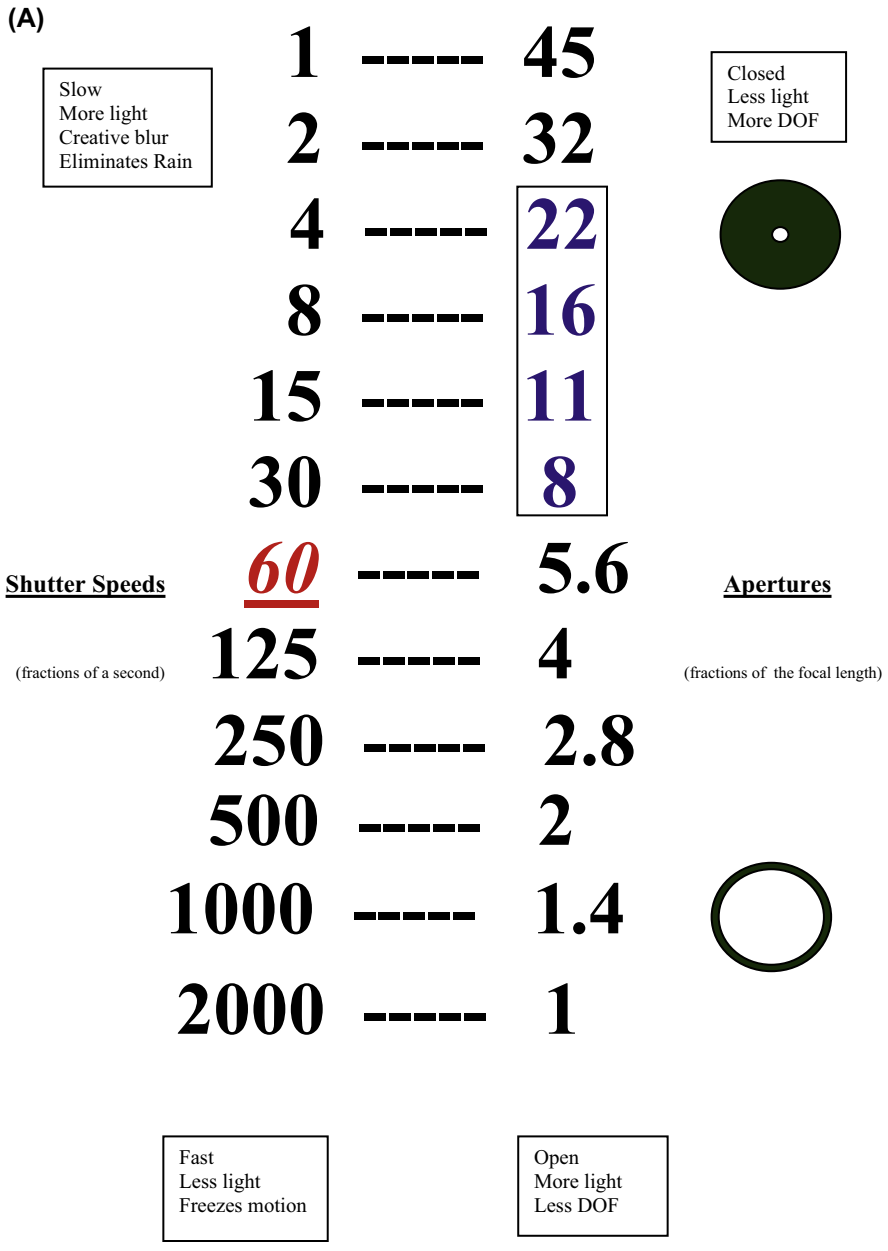


FIGURE 4.41
(A) Reciprocal exposures: pairs of f/stops and shutter speeds all with the same exposure. (B) Reciprocal exposures: various combinations of shutter speeds and f/stops.
See also http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646.

(B)

Reciprocal Exposures

The same exposure may be obtained from a variety of different exposure settings. A smaller aperture may be used as long as a longer corresponding shutter speed is used. A wider aperture may be selected as long as a corresponding shorter shutter speed is used. Each change in apertures either halves (with smaller apertures) or doubles (with wider apertures) the light allowed to reach the film. Each change in shutter speeds either halves (with faster SSs) or doubles (with slower SSs) the light allowed to reach the film. Selecting an exposure that halves one variable while doubling the other variable results in the same exposure. Why alter exposure settings? To maximize DOF with smaller apertures, or to freeze motion with faster shutter speeds.

In the below example, F-2.8, 1/2000 would be an excellent choice to freeze motion; while F-16, 1/60 would be the best selection to maximize DOF while still being able to handhold a camera with a 50 mm lens.

However, all seven combinations would result in good exposures under the same lighting conditions.

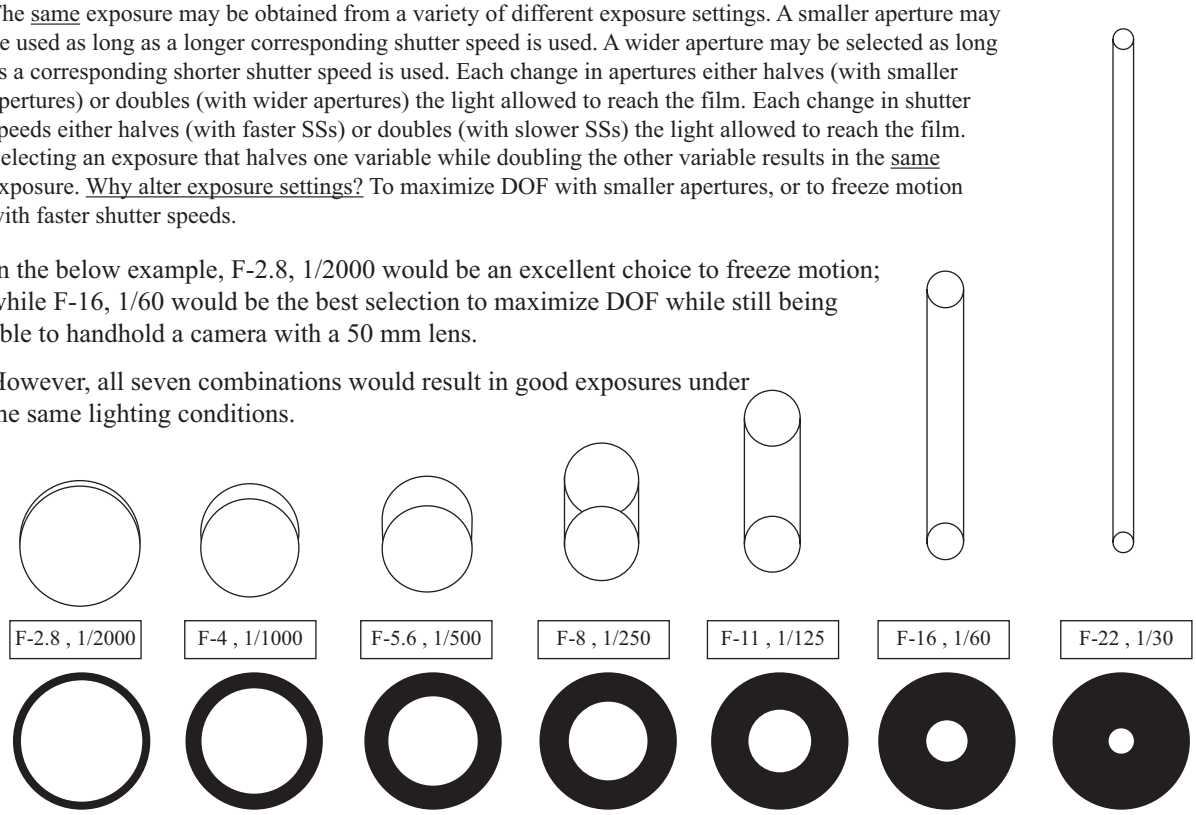


FIGURE 4.41 CONT'D

This will allow you to align different shutter speeds with different f/stops. After any one pairing of shutter speeds and apertures has been aligned, all the other pairings of shutter speeds and f/stops are also reciprocal exposures for a particular lighting condition, and all pairings will result in a proper exposure.

Notice in the shutter speed continuum, the *60* is shown in italics, and in red. This is an indication that a shutter speed of 1/60th of a second is the primary shutter speed to be used when hand-holding a 35 mm camera with a 50 mm lens on it; 1/60th of a second should be considered the primary shutter speed used at crime scenes.

Notice in the f/stop continuum, the f/stops 8, 11, 16, and 22 are enclosed in a rectangle. This is an indication that these f/stops produce the best depth of field of all the f/stop choices and should be regarded as the most frequently recommended and used f/stop selections. F/stop numbers and their relationship to depth of field will be revisited at length in the next chapter. For now, however, consider this. Because most crime scenes are relatively static, with the crime scene and the evidence within the crime scene fixed in place, the need to control motion is usually secondary to the need to maximize depth of field. Because most of the photos at the crime scene will be taken with a 50 mm lens, 1/60th of a second is the optimal shutter speed to use with that lens. Because it is important to have the best depth of field range when photographing the crime scene and the evidence within it, you will want to use the smallest apertures as much as possible.

If both are true, and they are, then a new Rule of Thumb for crime scene photography exposures can be developed.

RULE OF THUMB 4.7

To the extent possible, most crime scene images should be captured with a shutter speed of 1/60th of a second in combination with one of these four f/stops: f/22, f/16, f/11, and f/8.

If you are about to depress the shutter button, and you are not using one of the exposure combinations mentioned in Rule of Thumb 4.7, you should consider altering your exposure combination until one of this Rule of Thumb's exposure recommendations is achieved.

As an example, consider a situation in which you are about to use a 1/125th of a second shutter speed and an f/11. Aligning the 125 and 11 on Fig. 4.41A shows all the other reciprocal exposures possible for the same crime scene lighting conditions. These include 30 and 22, 60 and 16, 125 and 11, 250 and 8, and 500 and 5.6, among others. The Rule of Thumb recommendation would be 60 and 16. What is the effective difference between the 125 and 11 and the Rule of Thumb recommended 60 and 16? Both will result in the same exposure. The f/16, however, will produce a better depth of field than the f/11 would. Why use an exposure combination that will produce less depth of field? Use this Rule of Thumb and change the exposure to 1/60 and f/16.

Sometimes you may become confused by a camera's design, which indicates only one exposure combination at a time. What is critical to remember is that even if the camera's metering system indicates one exposure combination is proper for a particular scene, many other exposure combinations will produce the exact same exposure value. You must choose wisely from these various possibilities to achieve your desired results. This is the **Theory of Reciprocity:** for every photo opportunity there are multiple exposure combinations to choose from.

This choice should be deliberate, not arbitrary. You should have a reason to choose one combination over the other. How do you choose? You must decide what you want the photograph to look like: do you want a long depth of field or a short depth of field; do you want to freeze motion or have the image show creative blur?

Fig. 4.41B attempts to make this same point about reciprocal exposures, but it tries to demonstrate the equality of the various reciprocal exposures in a graphic way. Some learn in different ways. These seven shutter speeds and f/stops all result in the same exposure. They result in the same amount of light reaching the digital sensor.

Reciprocity Failure

Sometimes, the theory of reciprocity does not work.

When film was the tool, there was frequently a tendency toward underexposure when long shutter speeds were used.

When would such situations occur? The need for long shutter speeds occurs when the ambient lighting is dim. In most of these situations, however, all you practically need to do is add electronic flash. When electronic flash is used, the necessary shutter speeds are very short. This will be elaborated on more in chapter "Electronic Flash."

However, the use of electronic flash will not be the answer at all times. This text will cover several situations when long shutter speeds are required. For instance, when you are photographing bloody residues enhanced with the blood reagent luminol, shutter speeds in the range of 45–90 s are typical. When you are fluorescing trace evidence with an ALS, long shutter speeds may be required to capture the dim fluorescence adequately.

Do digital cameras also suffer from **Reciprocity Failure**? With digital cameras, the effect of long shutter durations is now called **Dark Noise**, which has been explained.

When a digital sensor is exposed for long time intervals in dim lighting situations, the result is often a "grainy" appearance to the image, where individual pixels are not properly recording colors and light levels accurately. Rather than smooth, evenly toned surfaces, a "noisy" digital image appears speckled with odd random colors.

The two images in Fig. 4.42 are crops of images which were taken with a digital camera in an almost completely dark room. A shutter speed of 7 min was required to obtain both images. The left image was taken "as is." It clearly shows the speckled "noise" that affects many digital cameras used with long shutter speeds. The right side of Fig. 4.42 was taken with a camera using a program called automatic noise reduction. The camera's computer can recognize "noise" and attempts to fix much of it.

The automatic noise reduction program has a great effect on the final product. Although the "noise" has not been completely eliminated, the image with automatic noise reduction is clearly superior to its "noisy" counterpart. There can be, however, too much of a good thing. Applying too much noise reduction to an image can degrade the image, or make the image appear a bit "softer" than you might like. Noise reduction levels should be applied with care.



FIGURE 4.42
Noisy: 7-min exposure.

THE REFLECTIVE LIGHT METER

The Light Standard: The 18% Gray Card

Some images will be properly exposed, some will be underexposed, and some will be overexposed. This is easy to see when looking at photographs. But how does the reflective light meter in the camera "know" that the f/stop and shutter speed selected allow the right amount of light to enter the camera? Most SLR cameras have light meters that measure the amount of light being reflected into the camera, but what standard is used to determine whether this amount of light is just right, not enough, or too much?

Fig. 4.43, which shows an **18% Gray Card**, is the standard. Many shades of gray exist. Only a gray card that reflects precisely 18% of the light that strikes it is the standard. This particular shade of gray is used because the real world, considering its light shades and dark shades and the various colors found in a "normal" scene, typically reflects 18% of the light that strikes it toward the camera.

Any author venturing into an explanation of reflected light meters and the 18% gray card would do well to at least briefly acknowledge Ansel Adams's Zone System, formulated in 1939–40. Because this method is often thought of as being an extremely technical and confusing way to determine proper exposures, a simplified selection of relevant ideas will be presented here. Consider a continuum from absolute black to pure white, with various shades of gray in between, where each gradation on the continuum is precisely 1 stop more or less light from an adjacent tone. An 11-step scale will be formed, with absolute black represented by the value 0 (zero) and pure white represented by X (Roman numeral ten). The shade or tone in the center would then be Zone V, which is a shade of gray that matches the 18% reflectance gray card. This is the tone which reflective light meters are designed to meter for.

Camera manufacturers know they will not survive long if they sell cameras that do not produce acceptable results most of the time. After extensive testing of myriad scenes reflecting differing amounts of light, it was determined that the "normal" scene at which camera owners would likely aim their cameras was a scene reflecting approximately 18% of the light that struck it. The 18% gray card, then, is a substitute for a "normal" scene.

If you were to become confused by the variation of objects within any particular scene and were unsure whether the scene was "normal," to ensure a proper exposure was obtained, you could use an 18% gray card as a scene substitute. In other words, the camera can be aimed at the 18% gray card, and a meter reading can be obtained from it. It is essential, however, that the 18% gray card was lit the same as your crime scene in question for this substitution to work.

An imaginary scene can provide an example. Consider, for instance, a sunny outdoor scene around noon. You would typically set ISO 100 on a digital camera. If using a 50 mm lens, set the shutter speed to 1/60th of a second. Then, compose the camera so the 18% gray card totally fills the frame. Ensure the 18% gray card is lit like the scene in question. In other words, if the crime scene is sunny, ensure the 18% gray card is sunlit; if the crime scene is shady, have the 18% gray card be covered with the same degree of shade. Finally, depress the shutter button halfway and take a meter reading to determine the necessary f/stop. Set the camera for that f/stop, compose, and focus on the real crime scene, and a proper exposure should be the result.



FIGURE 4.43
18% gray card. (The #429 is the author's old badge number.)

Reflective Light Meters

Thirty five millimeter SLR cameras typically have reflective light meters built into them, designed to meter/measure the amount of light reflected from the scene, through the lens, into the camera. The reflective light meter is inside the camera body, near the sensor, so it can properly determine the amount of light required to properly expose the image on the sensor.

Many professional photographers, although not any of the crime scene photographers this author has known, will use an **Incident Light Meter** to determine the lighting required for a proper exposure. This is a hand-held meter that the photographer will hold near the person or object being photographed. It is designed to measure the amount of light falling on the subject rather than the light reflected from the subject toward the camera. An incident light meter is very precise in controlled situations, where the photographer can stage a variety of lights at different distances and at different intensities to achieve the desired effect. At crime scenes or accident scenes, it is normally too impractical to consider multiple lighting situations.

Several kinds of reflective light meters are available in SLR cameras. Lower-priced, student cameras will frequently have only an averaging or center-weighted meter. As the cost of the camera body goes up, usually the camera will feature other metering options.

Averaging/Center-Weighted Meters

Averaging/center-weighted meters measure most of the light coming in through the lens, emphasizing the light from the center of the area of view, because that is where most people place the important aspects of their photographs (see Fig. 4.44A). When a photographer is taking a meter reading, only the light coming in from the area shown by the ellipse will be considered in determining the meter reading. Most cameras, even if they have other meter options, will have this metering option.

Spot Meters

Spot meters measure only the light reflected from a very small area of the center of the viewfinder (see Fig. 4.44B). As a result, the photographer can be very specific about what area of the photograph he or she wants properly exposed, disregarding the rest of the scene. For example, imagine trying to properly photograph your child during a school play. Some areas of the stage may be brightly lit, and other areas of the stage may be very dim. Should these areas be considered when the concern really is only with the light reflecting from just one particular child? In this situation, a spot meter would be very useful to determine the light being reflected from just one part of the overall scene. The crime scene equivalent to this is surveillance photography. Other aspects in the field of view may be irrelevant, so by placing the spot meter only on the subject of interest, just the light reflected from the subject will be calculated into the exposure reading. Lighting extremes around the periphery will be ignored.

Different cameras have spot meters of various sizes, and some may have variable-sized spot meters available. The size of the spot meter is usually indicated in the viewfinder, so the photographer can place it carefully where needed.

Matrix Meters

Various matrix-metering systems exist, sometimes with elaborate geometric configurations, which break up the light coming in through the viewfinder into a series of grids and assign different values to the light coming in from the various grids (see Fig. 4.44C).

These systems are a result of very extensive research and development and are usually found on only the higher-priced cameras. A minicomputer in the camera uses very complex algorithms to "weigh" the differing amounts of light coming in from the various grids. For instance, if the grids in the center of the viewfinder received very limited light reflection and several very bright grids were in one of the upper corners, the computer would recognize that situation as a person in the center of the viewfinder being backlit by the sun or moon in the distance and recommend an exposure designed to properly expose the dimly lit center of the viewfinder. Matrix-metering systems produce very accurately exposed photographs. If a camera has a matrix-metering system, it is normally preferred as the standard metering system.

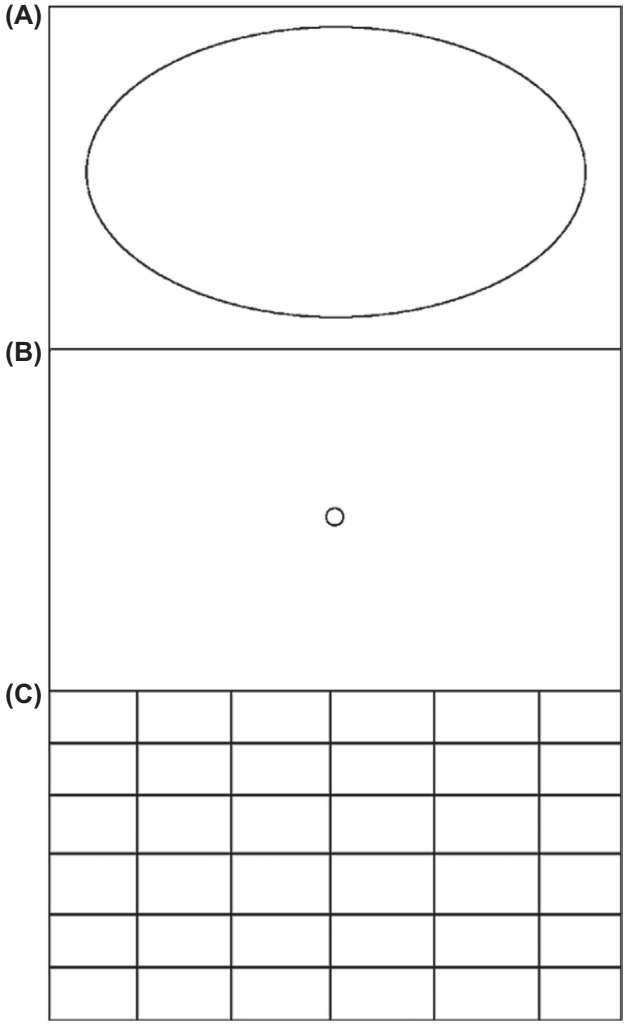


FIGURE 4.44
(A) Center-weighted metering pattern. (B) Spot meter pattern. (C) Matrix-metering pattern example.

WHAT TAKING A METER READING ACTUALLY LOOKS LIKE

Now that we have covered the four variables related to determining an exposure, let us put it all together and revisit the order these variables are used to determine an exposure of the camera.

- Usually, the **ISO** is selected first, and this is based on the current lighting on the area to be photographed. Recall we suggested an ISO 100 for midday sunlit scenes. For early in the morning, late in the afternoon, night time, and indoor photography, an ISO 400 was recommended as a starting point. This can be adjusted as needed, but it will get us in the ballpark.
- We should set the **shutter speed** to avoid camera shake and image blur caused by hand-holding a "normal" lens, very frequently a 50 mm lens. This usually calls for a 1/60th of a second shutter speed.
- The third exposure variable is to **take a meter reading** of the reflected light coming from an area we have chosen to photograph. Taking a meter reading is done by composing on a scene, and while still composing on that scene, simply pressing the shutter button half way. While looking through the viewfinder, and depressing the shutter button half way, we can see not only the area we wish to photograph but also an exposure continuum usually ranging from a (+) to zero (0) and then to (−). See Fig. 4.45. These three images show a (0) and then between the (+) an (−) symbols there are two dots to the left and right sides of the (0). The first dot on either side of the (0) represents a +1 and −1, respectively. The second dots represent a +2 and −2, respectively. Notice there are three hash marks under the (+) to (0) to (−) continuum which lead from the (0) to the first dot on either side of the images of Fig. 4.45. This is an indication that the f/stops have been set to vary by thirds of a stop.

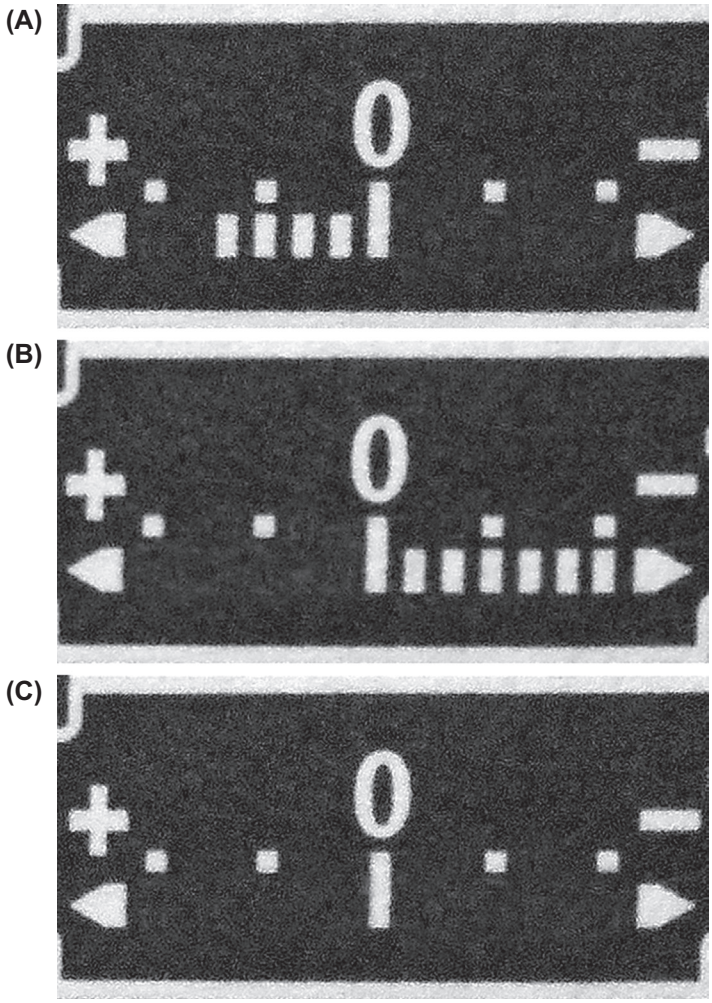


FIGURE 4.45
(A) Meter indicating a +1⅓ exposure. (B) Meter indicating a –2 exposure. (C) Meter indicating a "proper" exposure.

When one depresses the shutter button half way, the exposure meter evaluates the currently set ISO, the shutter speed, the f/stop (the f/stop used for the previous image), and the lighting coming in through the viewfinder. It then graphically informs the photographer what the result would be if the shutter button was depressed all the way. Most of the time, what you will be seeing is that the meter is indicating that the image being currently being composed will result in either an overexposure or underexposure.

Fig. 4.45A is indicating the exposure will result in a +1⅓-stop overexposure; the Fig. 4.45B is indicating the exposure will result in a –2-stop underexposure. The goal is to achieve a "proper" exposure, which is indicated in the Fig. 4.45C, where there are no other hash marks except one beneath the (0).

Since we do not want an overexposure or underexposure, we now know what type of exposure correction is needed, as well as precisely how much of that correction is required.

In reality, it would be possible to affect any exposure corrections necessary by changing either the ISO, the shutter speed, or the f/stop. As a matter of fact, since this exposure correction should be done while the photographer maintains the same composure of the scene, the two easiest choices are to change either the shutter speed or f/stop, because those two settings can usually be changed just by rotating a dial with the right index finger while maintaining the same composition. However, since the shutter speed is currently set to the optimal 1/60th of a second, the shutter speed is usually not the exposure variable adjusted.

This means, for adjusting exposures while looking through the viewfinder, we normally vary the f/stop settings to eliminate the hash marks under everything except the (0), as seen in the Fig. 4.45C.

"NORMAL" AND "NON-NORMAL" SCENES

As stated previously, the reflective light meter built into the SLR camera body is designed to provide proper exposures for scenes that reflect 18% of the light that strikes them back toward the camera. These can be considered "normal" scenes. Reflect on those occasions when you have usually taken photographs outside your work environment. These include taking photos of family gatherings, vacations, loved ones, pets, and so on. What about them makes them "normal" scenes? They contained a variety of colors and objects that were both black and white and gray. White objects reflect a lot of light, black objects reflect little light, and gray objects reflect some degree of light in between the extremes. Colors also reflect a variety of light intensities. When thrown into one scene, the average of the light reflected back from a "normal" scene toward the camera is 18%.

"Non-normal" scenes reflect more or less light than the typical 18% that SLR camera meters are designed to deal with. The average photographer encounters these types of scenes less frequently. In these situations, the exposure results can sometimes be less satisfactory. You may notice in these situations that your images came back a bit overexposed or underexposed. Why?

Imagine how a reflective light meter "reasons." Designed to provide proper exposures for a scene that reflects 18% of the light that struck it, when the situation in fact does reflect that amount of light, the reflective light meter balances the four exposure variables: shutter speed, f/stops, film speed (or digital equivalent), and the light reflected from the scene. A proper exposure is the result. When the camera knows the ISO rating of the film within it, and it knows the shutter speed selected by the photographer, and the camera is composed on a "normal" scene reflecting 18% of the light striking it into the lens, the meter determines the necessary f/stop for a proper exposure. The f/stop recommended completes the four essential elements of the proper exposure triangle. This is what occurs at a "normal" scene.

Remember, however, that each of the four exposure variables comes in 1-stop increments. For example, a 1/60th shutter speed can also be changed to 1/30th (+1) or to 1/125 (−1). An f/11 can be changed to f/8 (+1) or f/16 (−1); 400 ISO also comes in 200 ISO (−1) or 800 ISO (+1) variants. Although "normal" scenes reflect 18% of the light striking them, other scenes reflect 36% of the light (+1), and some scenes can reflect just 9% of the light that strikes them (−1).

Now consider a "non-normal"scene. Consider the situation in which it has been snowing and your children have just successfully built their first snowman of the winter season. As a proud parent, you must document the achievement with a photograph. As the children stand around the magnificent snowman, you fill the camera frame with a scene that is predominantly white. Naïvely, you trust the camera metering system and use the recommended f/stop to take the photograph with your SLR. You drop off your camera's memory card at the nearest drugstore, and await proof that you are the best photographer on the block. The result comes back improperly exposed! Your first inclination is to accuse the drugstore developer of incorrectly exposing your perfectly exposed images. If you return to the drugstore processor and make this complaint, after several minutes of reprocessing your images, the processor will probably provide you with a print that looks "properly" exposed. You smile to yourself, feel vindicated in your original assumption the processor botched the original exposure, and leave happily knowing you are, in fact, the camera expert you have always thought you were.

Are you correct on either count? Had your original exposure calculations been the right ones? Had the processor incorrectly processed your correctly exposed images? No. No. And, no.

Consider your original exposure first. Presume, for the sake of argument, that white snow reflects approximately 80% of the light that strikes it. Here is what the camera meter encountered when you pressed the shutter button half way:

- The ISO is known.
- The shutter speed is known.
- The scene reflectivity one that reflects 80% of the light is known.

If reflecting light meters could talk, this is what it would have said to itself: "Something is wrong. This is not what I am designed to deal with. I am receiving too much light. How should I resolve this dilemma? I will presume the photographer is aiming the camera at a 'normal' scene that happens to be lit by an unusual amount of light. I will, therefore, provide a proper exposure for this particular scene as if it was a 'normal' scene lit with a normal amount of light; 80% is too much. I know exposure stop increments are expressed as halves and doubles. Half of 80% is 40%. That is still too much light. Half of 40% is 20%. That is close enough to the 18% I am expecting for a 'normal' scene. I will recommend an f/stop to the photographer that in effect underexposes the scene by 2 stops. That will be the proper exposure for a 'normal' scene lit 'normally.' That will prove I can be trusted to perform as designed."

The "−2 f/stop" is an f/stop that is 2 stops smaller than would have been appropriate for a "normal" scene lit "normally." The result is an underexposed negative. How much underexposed? 2 stops underexposed. See the Fig. 4.46A, for the metered exposure, and the Fig. 4.46B, for the +2 exposure to correct **"Dirty Snow."**

If a film processor "correctly" prints this underexposed image and the result is an underexposed print, has the processor made a mistake? Technically, "no." In this scenario, however, a complaint was made, and the processor took the same image back into the processor and later returned with a print more acceptable to its owner. Is this new "properly" exposed print proof that the originally underexposed print was incorrectly printed? Technically, no. Processing an underexposed negative into an underexposed print is not a mistake. It is certainly not good for the processor's business, but it is not a mistake.

Remember, underexposed and overexposed negatives can frequently be "corrected" so that more acceptable prints are the result.

Now examine a scenario in which the photographer is presented with an abnormally dark scene. This time, the example is related to crime scene photography. Several cars in a neighborhood have had their tires slashed, and a suspect has been caught with a single-edged knife. All the puncture marks in the tires show the blade used had a single sharp edge. Anticipating that a few good photographs might demonstrate this fact to the jury better than just a verbal report, photographs of the puncture marks are made. As the photographer composes the first close-up image of a puncture mark and takes a meter reading of the area, presume that black tire rubber reflects approximately 5% of the light that strikes it. How will this image look when developed?

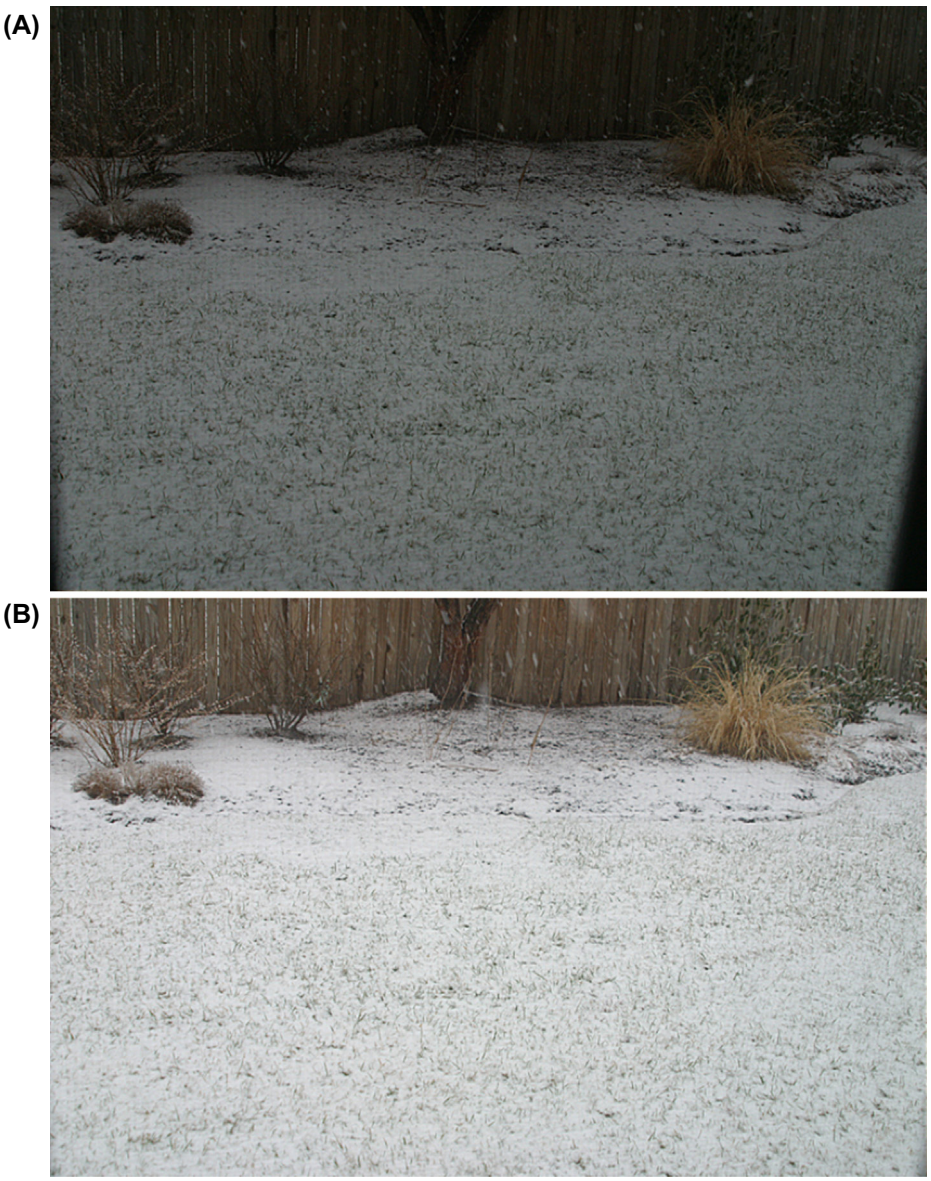


FIGURE 4.46
(A) Meter reading suggestion results in "dirty snow." (B) Meter reading adjusted for a +2.

The black tire reflects just 5% of the light toward the camera. The meter, expecting a "normal" scene or 18%, knows a +1 exposure would result in an exposure for a scene reflecting 10% of the light. Not enough. The meter knows that a +2 exposure would result in an exposure for a scene reflecting 20%, which is very close to 18%, so the meter is happy and recommends this +2 exposure to the photographer. When the naïve photographer uses that exposure recommendation, the tire photos are all 2 stops overexposed. See the Fig. 4.47A for the tire exposed by trusting the light meter, and the Fig. 4.47B after making a −2-stop correction.

Knowing this is how reflective light meters work, we must be smarter than they are, and know when to trust them and know when they will probably be wrong. And, if they will probably be wrong in reoccurring circumstances in precise exposure increments, we must learn how to correct the mistakes they are likely to make.



FIGURE 4.47
(A) Meter reading of a tire. *(Courtesy of R. Thompson, NIST and GWU MFS student.)* (B) Meter reading with a −2 setting.

The "Normal" Scene

The "normal" scene reflects 18% of the light that strikes it. Fortunately, most scenes are "normal." This means that not a lot of exposure determinations it, the camera meter, makes will need to be corrected: for the most part, you can trust the camera's built-in light meter to provide for proper exposures.

If you are pushed to estimate what percentage of crime scene photography involves "normal" scenes, a number has not been indicated in the literature. What is "normal" for laymen taking photographs is certainly not what is encountered by crime scene photographers. Crime scene photographers have to be very aware of times when they are about to photograph a "non-normal" scene and how to correct the resultant exposure differences.

"Non-normal" Scenes

Four well-recognized "non-normal" scenes will require exposure compensations to provide for proper exposures:

- Predominantly light-colored scenes
- Predominantly dark-colored scenes
- Scenes with a lot of sky in the field of view
- Backlit scenes or scenes with both bright highlights and dark shadows in the same composition.

Exposure compensations are required, because trusting the reflective light meter to provide the "correct" exposure in these situations will lead to unsatisfactory results. Just knowing that the meter cannot be trusted when dealing with a "non-normal" scene is the first step. Knowing what exposure compensation is required is the second step. The goal is to capture a properly exposed digital image. It is always preferable to expose the image properly at the time of capture, rather than have to resort to digital darkroom corrections.

Predominantly Light Scenes

The nature of crime scene photography presents us with many light-colored scenes and objects. Just as the snowman scenario mentioned earlier resulted in an underexposed image, if the camera meter is trusted, so will all outdoor crime scenes that include large areas of snow. This will be the result not only when overall images of the crime scene are taken, but also when midrange photos and close-up images of individual items of evidence lying in the snow are taken.

To compensate for this tendency toward underexposure, you will need to manually alter the exposure recommendation offered by the meter. Knowing that snowy scenes are typically underexposed by the meter by approximately 2 stops, take the meter reading as usual, and then manually open the aperture 1½–2 stops wider from what the meter recommended.

For many, this lighting situation seems counterintuitive. If the crime scene reflects too much light, should you not be reducing the light to ensure a proper exposure? This is the reasoning used by many who do not understand that the reflective light meter is automatically making this compensation already. If you use your "gut" feeling, and reduce the light even more than what the meter recommends, the result will be greatly underexposed images.

A mnemonic is useful here. Remember the phrase "dirty snow." If the reflective light meter is relied on when taking images of snowy scenes, the result will be "dirty snow." What is "dirty snow"? It is dark or underexposed snow. What is the cure for "dirty snow"? Open up 1½–2 stops.

Another predominantly light-colored type of evidence should be mentioned here: Caucasian skin. Crime scene photographers encounter the need to photograph this type of evidence frequently. Whether it is a nude Caucasian cadaver at an autopsy or just a wound or bruise to one part of the body, this type of evidence is frequently encountered. The need to fill the frame of the camera with Caucasian skin recurs frequently enough to recognize the need to properly expose this type of evidence. Although myriad shades of skin are present in all races, "normal" Caucasian skin has been measured to reflect approximately 36% of the light that strikes it. That is precisely 1 stop lighter than a "normal" scene, which the reflective light meter is expecting.

The result: the meter will tend to cause a 1-stop underexposure of Caucasian skin, if it is trusted. The compensation required, then, is to take a meter reading of the Caucasian skin and then open up +1 stop more from what the meter suggests. See Fig. 4.48. Trusting the meter results in a 1-stop underexposure. A +1 exposure shows the skin and the bruise as the eye would have seen it. A +2 exposure causes an overexposure.

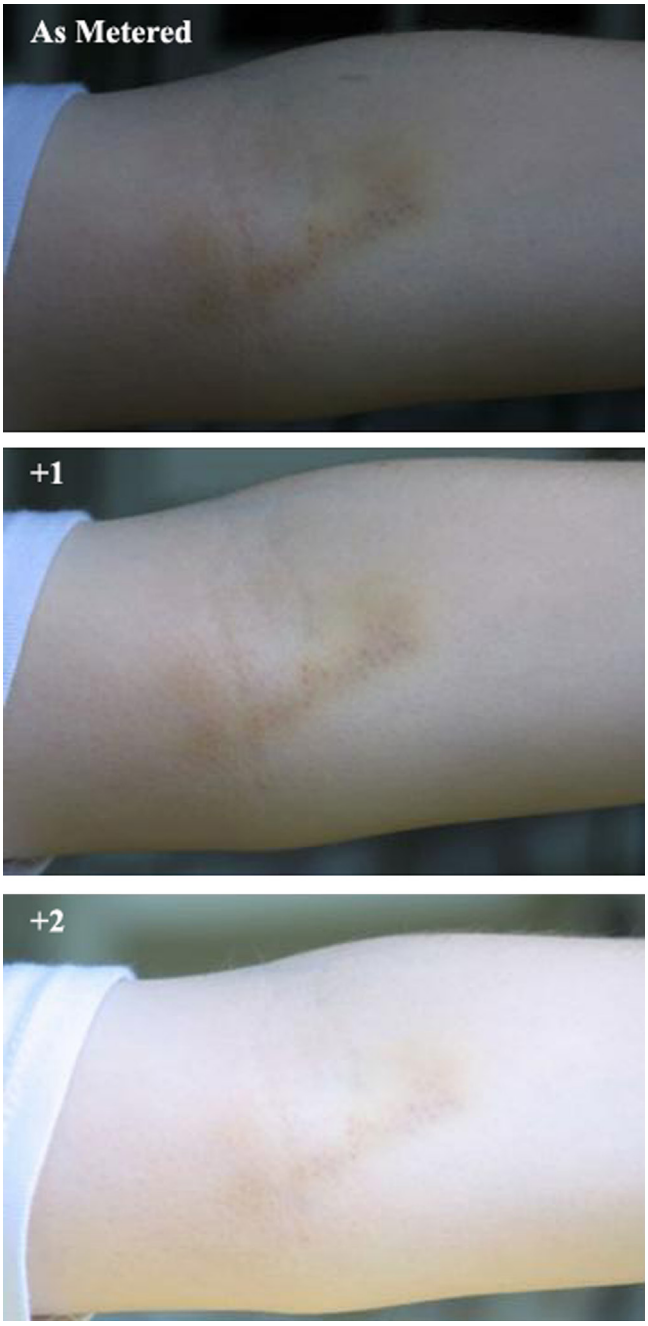


FIGURE 4.48
Bruise on Caucasian skin, 0, +1, and +2.

Crime scene photographers frequently encounter other light-colored scenes. Most rooms have light-colored walls. When you are taking **Interior Overall Photographs** of crime scenes and the composition is predominantly of a light-colored wall, an exposure compensation is almost always required.

How much? Interior walls are seldom as bright as snow and are closer to the reflectivity of Caucasian skin, so open up 1 stop from what the flash calculator dial suggests. Flash theory will be covered in chapter "Electronic Flash," but the need to photograph light-colored walls occurs so frequently, it is necessary to mention it in this chapter.

Just as snow presented an exposure compensation necessity, so too would scenes with a large amount of sand in them. Although sand may seem a darker shade than snow, its crystalline nature reflects enormous amounts of light toward the camera. Sand requires the same exposure compensation as snow. With a sandy crime scene, take a meter reading, and open up +1½ to +2 stops.

The need to make an exposure compensation occurs only when the viewfinder is filled with a light-colored scene. It is not required just because a light-colored object is being photographed. If, for instance, a light-colored soccer ball is noticed to have some blood drops on it and it is currently lying on a grassy lawn, the meter may be trusted if quite a bit of grass is also in the viewfinder. It is only when the viewfinder is almost totally filled with the light part of the scene that an exposure compensation is required. If the light-colored object is just one item in the field of view and the meter will be receiving reflected light from other normally toned objects, the meter can be trusted.

What if the situation is "borderline"? In these situations, bracket. **Bracketing** will be discussed shortly.

Predominantly Dark Scenes

Any time the viewfinder is filled with a relatively dark object, such as the black tire mentioned previously, the reflective light meter is not to be trusted. In this case, the mnemonic "dirty snow" can again help. If light-colored scenes tend toward underexposure, predominantly dark scenes will tend toward the opposite: overexposure. That is the left exposure of Fig. 4.49. The middle image is a –1 exposure, and then the right image is a –2 exposure.

Consider a situation in which a black sweatshirt has been discarded by a suspect while fleeing a crime scene. If the sweatshirt is viewed as just one item in a scene showing the general area where the sweater was found, then an exposure compensation will not be needed. In this case, the sweatshirt is just one dark object among other "normally toned objects."

Once the sweater has been photographed within the scene, the next series of photographs would be close-up photographs of just the sweater filling the frame of the camera. In this situation, the camera meter will be fooled into recommending an exposure to the photographer that overexposes the sweater.

The black sweatshirt photographed in Fig. 4.50A, as metered will come out looking 2 stops overexposed: grayish. Decreasing the exposure 1 stop improves the image, but the sweatshirt still does not look as black as it really was (Fig. 4.50B). Only a 2-stop decrease in exposure accurately captures the original look of the black sweatshirt (Fig. 4.50C). Unsure whether a –1 or –2 stop exposure is correct for a particular item of dark evidence. Photograph it both ways and compare the images to the sweatshirt.

Large Amounts of Sky

When a large portion of the scene/composition turns out to be the sky, realize that the sky reflects more than normal amounts of light toward the camera. Although your eyes adjust well to this bright light source, making it easy for you to forget the sky is much brighter than any objects reflecting normal amounts of light, digital sensors will be adversely affected by this exposure situation. Crime scene photographers are presented with this situation every time they take **Exterior Overall Photographs** of crime scenes.

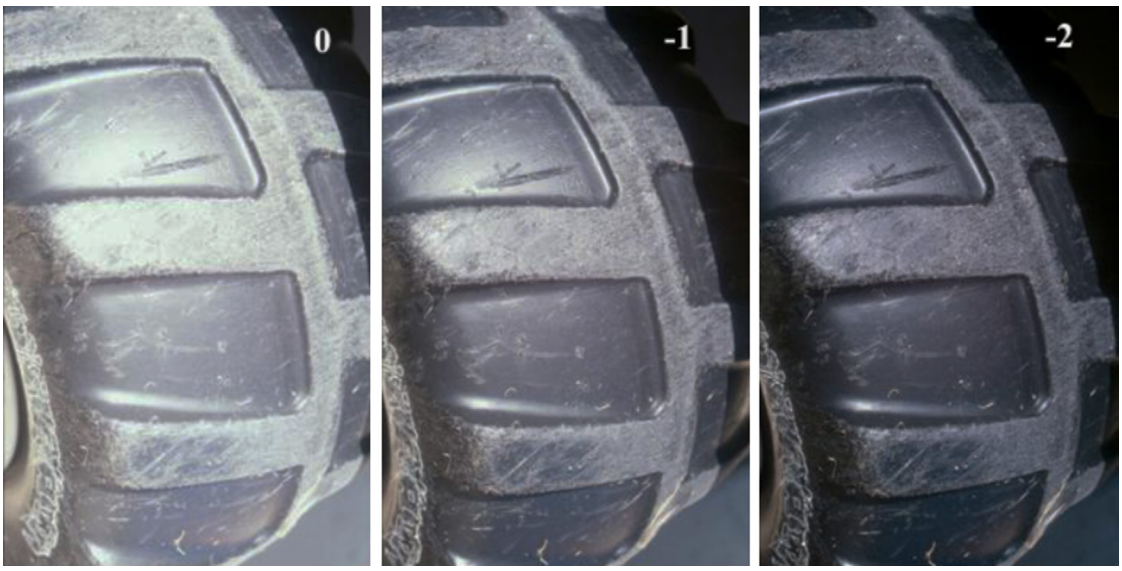


FIGURE 4.49
Tire, as metered, –1, and –2.

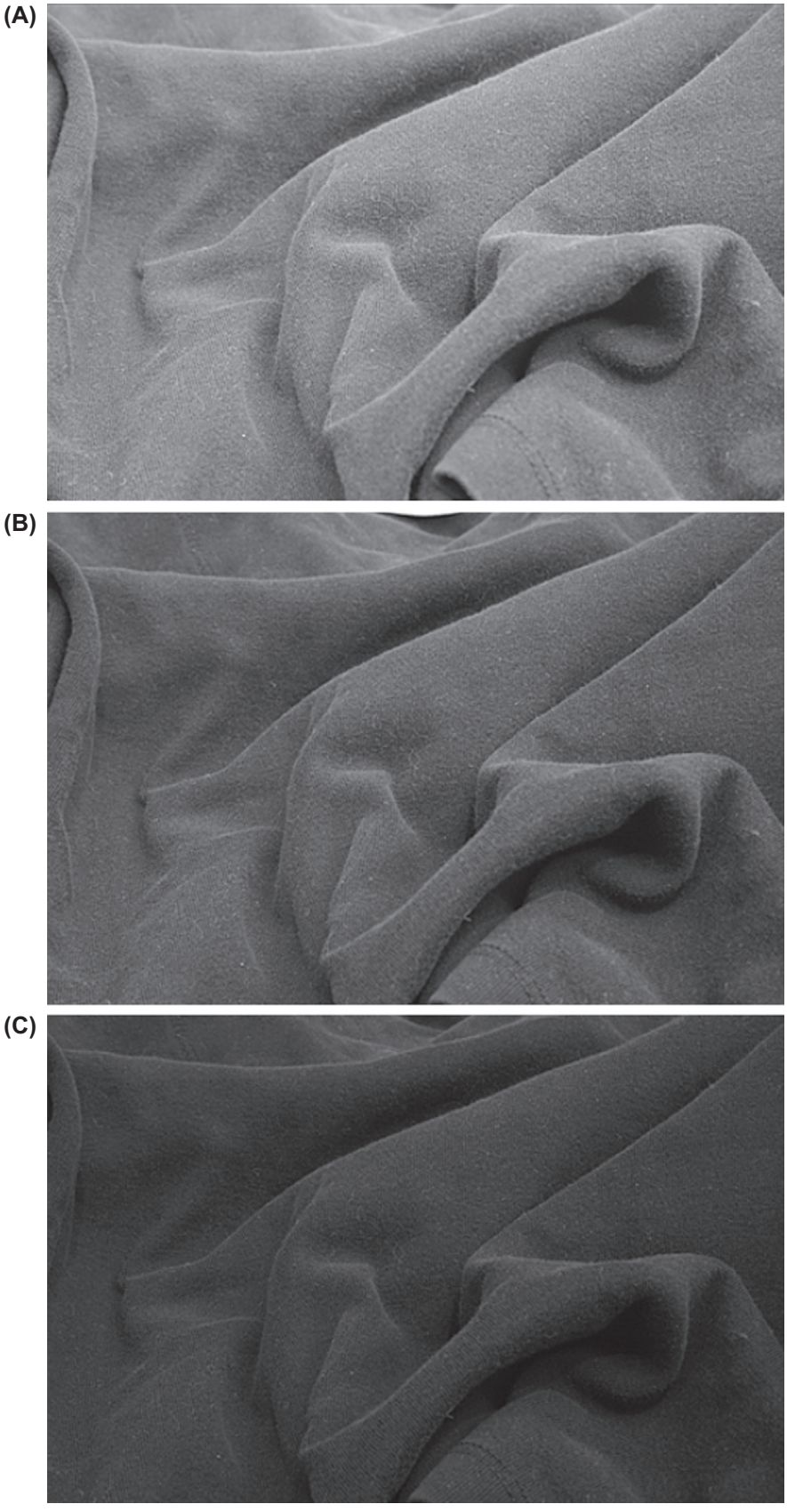


FIGURE 4.50
Black sweatshirt, as metered, –1, and –2.
Courtesy of Denise Sediq, GWU MFS student.



FIGURE 4.51
Left: Bright sky leading to underexposure. *(Courtesy of D. Goodwyn, GWU MS student.)* Right: Metered without the sky in view. *(Courtesy of D. Goodwyn, GWU MS student.)*

You will take photographs of the building the crime occurred in, and frequently this includes quite a bit of blue sky in the background. If a substantial amount of this particular field of view is much brighter than "normal," the meter can only average that large amount of light, add it to the light otherwise reflected from the scene, and come up with an exposure recommendation "suitable for both." The meter will unsuccessfully attempt to provide for a proper exposure of the sky and a proper exposure of the building at the same time.

The result will frequently be an underexposed building, but the sky will look very close to the way you remember it. Of course, having the sky properly exposed at the expense of the exposure to the building is counterproductive. The intent of the image is to have properly exposed the crime scene building (see Fig. 4.51). One of the main purposes of exterior overalls is to show possible points of ingress or egress that suspects may have used. If the building is grossly underexposed, these aspects will be lost.

What is the exposure compensation required to provide proper exposures of buildings when a large amount of sky is also in view? To determine the correct exposure, eliminate the problem. In this case, the sky is ultimately causing an incorrect exposure of the building. So, when taking a meter reading of the building, eliminate the sky. This can easily be done in one of three ways.

First, simply tilt the camera down: lower the camera until the top of the building is at the very top of the field of view, and then take a meter reading without the sky in view. Set the camera for this meter reading, and then recompose back to the original scene with the sky in the field of view. Take the photograph.

Second, if you are using a zoom lens as your primary lens, zoom the lens to its extreme telephoto setting, composing this narrower field of view so it includes only the building façade, and take a meter reading that excludes the sky. Set the camera to that exposure recommendation, reset the lens back to the original focal length, and take the photograph.

Third, if your camera has a spot meter, select that metering mode, and then aim the spot meter so it is on the façade of the building. Only what is covered by the spot meter will be considered when the exposure is determined, and the rest of the scene will be irrelevant. When this shot has been taken, do not forget to change your spot meter back to the matrix-metering mode.

In all three instances, the sky will then be a bit overexposed, but the building will look properly exposed. When you are a crime scene photographer, this is about as good as you can do. There are, of course, half-frame ND filters, which provide shading for only half of the view area. Landscape photographers will position the shaded area so that it covers the sky and then meter the landscape. The result is a landscape that is properly exposed, and a sky that also looks great. However, not many law enforcement agencies are providing half-frame ND filters to their crime scene photographers.

Backlit Scenes and Other High-Contrast Scenes

When the primary subject is photographed while being backlit, the primary subject usually ends up looking underexposed in photographs. This is another situation in which a bright light source is in the field of view, similar to the sky situation. The reflective light meter is designed to properly expose a scene that has a normal range of tones in the scene with the lighting for the scene uniform throughout the scene. When any part of the scene diverges from these uniformities, the meter will have difficulties providing for proper exposures.

In Fig. 4.52, a meter reading was taken of the bright sunlit area in the background. Taking a meter reading ensures the background will be properly exposed. Without doing this, the background may look grossly overexposed in the resulting image. However, because the subject was not directly sunlit, this exposure combination results in the primary subject, in Fig. 4.52, being underexposed. This underexposure of the primary subject is compensated for with fill-in flash. Fill-in flash will be completely covered in "chapter "Electronic Flash." For the purposes of this chapter, however, be aware that any time a scene has both bright and dark areas in the same scene, it will probably be necessary to use fill-in flash to ensure both areas receive proper lighting for an overall proper exposure.

A brief explanation here will further explain the three images of Fig. 4.53. The exposure for the sunlit background was determined by directly metering that area. The viewfinder was filled with the sunlit area of the scene, and a meter reading was taken. It is important to note that the overall scene was not metered. This would include both the sunlit background and the more dimly lit primary subject. Doing so would result in an improper exposure determination for the sunlit background. Once the exposure for the sunlit background was determined, the camera was set for that exposure combination. A sunny scene would have called for a 100 ISO film. To hand-hold a camera with a 50 mm lens on it would have meant that a shutter speed of 1/60th of a second would be normal. A midday sunny scene frequently requires an f/22, as will become clearer as this chapter continues. Then an electronic flash was set to properly expose the primary subject, the keys under the car. The result is that the sunlit background is properly exposed, while at the same time the primary subject in the foreground is also properly exposed.

There may also be high-contrast scenes, which include both bright sunny areas and dimly lit shady areas in the same area of the same scene (see Fig. 4.53). Of course, if you can recompose to eliminate one of the lighting extremes, that is one way to solve the improper exposure tendency. But many times this is impossible. On bright sunny days, the sunlit area is often directly adjacent to an area in deep shadows. When wide extremes in the light levels of a scene exist, you must realize that the **Dynamic Range** of the digital sensor results in one of the extremes being improperly exposed. Fill-flash is the cure to lighting extremes.

Again, avoid the temptation to merely take a meter reading of the entire scene, believing that doing so will simultaneously cure the underexposure of the shady areas of the scene and the overexposure of the sunny areas of the scene. This "average" exposure fails to properly expose both areas at the same time. It improperly exposes both parts of the scene by around 2 stops.

As mentioned previously, the proper solution is to use fill-in flash in this situation.



FIGURE 4.52
Left: Backlit scene: primary subject underexposed. Right: Backlit scene: corrected by fill-in flash.
Courtesy of Denise Sediq, GWU MFS student.

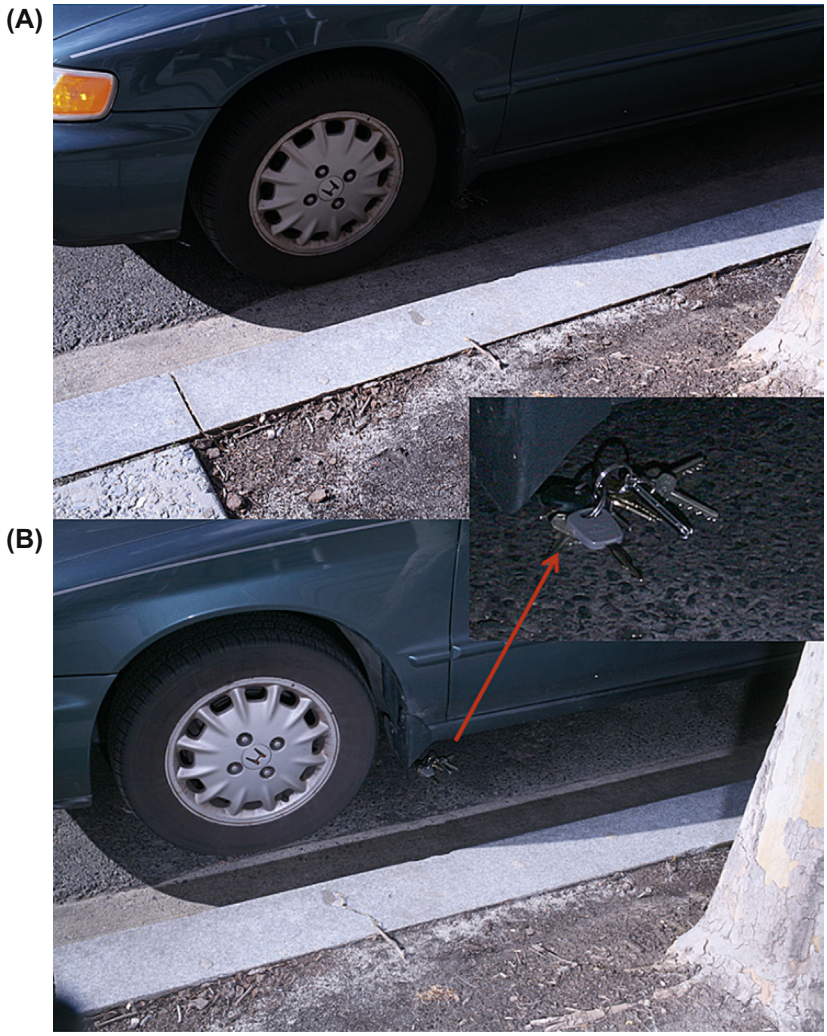


FIGURE 4.53
(A) High-contrast scene, exposed for the sunny area. (B) Fill-in flash allows the keys to be seen. Insert: crop of keys.

TOOLS FOR DETERMINING "PROPER" EXPOSURES WITH TRICKY SCENES

How can you determine whether the light reflected from a particular scene is "average" or is a scene reflecting 18% of the light that struck it? Is there a way to be better assured that you are properly metering a particular scene? Do the camera and/or meter somehow alert you to a problematic scene? These questions, and their concerns, trouble most photographers at one time or another. Even though it is probable that 80–90% of crime scene photos are of "normal" scenes and the camera's reflective light meter can be trusted in those instances, what can be done when the "non-normal" scene is encountered or when a scene with a "tricky" exposure is encountered?

First, try to remember the exposure compensations recommended previously. If, however, you should "go blank" at any particular time when trying to determine the correct exposure for a complex scene, consider using one of the following "tools" for determining proper exposures.

Meter the 18% Gray Card

If any doubt exists about whether a particular scene is reflecting the 18% "normal" amount of light, try filling the viewfinder with the 18% gray card and take a meter reading from it. Were the original metering of the scene and the metering of the 18% gray card the same? If not, go with the meter reading of the 18% gray card.

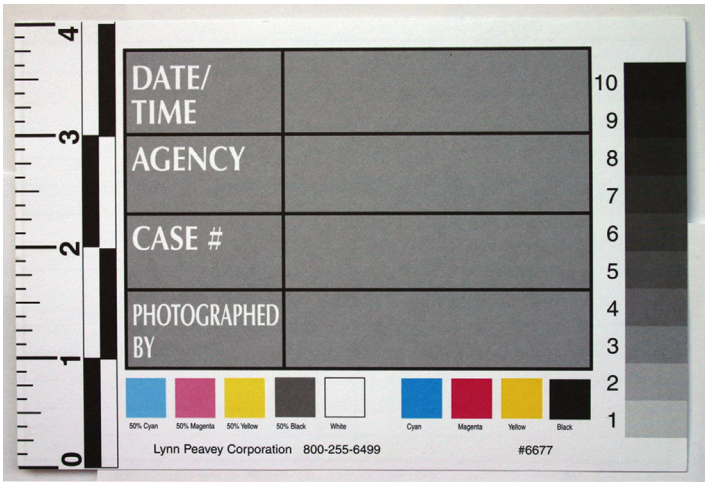


FIGURE 4.54
Photo identifier including an 18% gray scale.

If it is lit the same way as the scene is lit, then you can set the camera for an exposure on the basis of the 18% gray card and use that exposure for the scene in question. If the scene is sunlit, the 18% gray card must also be sunlit; if the scene is shady, the 18% gray card must also be covered in the same density of shade. Do not use the 18% gray card when the scene is sunlit but the 18% gray card is in the shade or when the scene is shady but the 18% gray card is sunlit; 18% gray cards come in a variety of sizes, so many photographers carry one in their camera bag, along with other essential equipment.

Official 18% gray cards can be purchased in any camera shop. Some crime scene product distributors produce **Photo Identifiers** that can also serve as 18% gray cards. See Fig. 4.54.

Photo identifiers will be further explained in the chapter "Electronic Flash," but for now, notice it has a substantial area that is gray. Surrounding that area is a black-to-white scale on the right side and pastel and solid colors on the bottom. The left side has inch increments. The total effect: this card is intended to reflect about 18% of the light that strikes it.

If any particular scene was judged to be confusing or a possible problem for the camera meter to expose correctly, you could fill the frame with this card, meter it, set the camera for that exposure combination, recompose on the scene in question, and take the picture.

Meter an Area of Green Grass

All the colors of the visible light spectrum can be converted into various shades of gray. It just so happens that green grass reflects about 18% of the light that strikes it, so it can be used as a surrogate 18% gray card if you do not have the 18% gray card handy. Fill the frame with green grass lit the same as the subject matter of concern, take a meter reading, set the camera for that exposure setting, recompose on the chosen subject matter, and take the picture.

Of course, not every crime scene is located near areas of green grass. Also, in some seasons, green grass is unavailable. Fortunately, other surrogate 18% gray cards are available.

Meter Well-Traveled Asphalt

No green grass in view? How about asphalt? Well-traveled asphalt also reflects about 18% of the light that strikes it. Newly laid asphalt, however, is very black and should not be used as an 18% gray substitute. After asphalt has been exposed to the elements for a while, it turns into a perfect 18% gray card substitute. Fill the frame with it; lit the same way as the scene of interest; take a meter reading; set the exposure; recompose; and take the picture.

Of course, not every crime scene is located near areas of well-traveled asphalt. Some of those crime scenes are also devoid of grassy areas. Is all lost? No.



FIGURE 4.55
Similar palm tonality.



FIGURE 4.56
M, A, S, and P exposure modes.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

Meter Your Palm

When all else fails, you can reach into your back pocket and pull out another tool to help determine a proper exposure. You can always meter your own palm. Your palm, regardless of race, reflects approximately 36% of the light that strikes it. In one of my recent classes at GWU, there was a great representation of students from all over the world. I asked a sampling of them to show me their palms (see Fig. 4.55). The palms were more similar than different. Half of 36% is 18%. Remember the theory of halves and doubles? Reflecting 1 stop more light than "normal," the palm will cause an exposure reading that is 1 stop underexposed, if that exposure reading is trusted. The camera, in effect, says to itself: "I expect 18% light; this is too bright. To give the photographer an exposure for 18%, I am going to reduce the exposure by 1 stop." Knowing this is how the meter "thinks," meter your palm and then open up 1 stop to arrive at a "proper" exposure.

Here, too, you need to have your palm lit the same as the scene of interest: sunny scenes require a sunny palm; a shady scene will require the palm be in the shade also.

You do not need to properly focus on the 18% gray card, green grass, well-traveled asphalt, or your palm when reading the meter. The meter does not care whether or not the reflected light is in focus. All it requires is the right amount of light.

Exposure Modes

There are four common exposure modes: manual, program, Aperture priority, and **Shutter Priority Exposure Modes**. These modes allow you to choose different options to determine how a proper exposure will be obtained. Camera exposure control dials will usually abbreviate these modes with either "M," "P," "A" or "Av," and "Tv" or "S" (manual, program, aperture priority or aperture value, and time value or shutter priority; see Fig. 4.56).

The other symbols on this exposure dial are directed at consumer or novice photographers not interested in learning all that an SLR camera system has available in it. These symbols will not be explained in this text. They do not represent true additional camera capabilities; they represent shortcuts to image making.

Manual Exposure (M)

With the **Manual Exposure Mode**, the photographer is responsible to manually set the f/stop and the shutter speed. The ISO must also be manually chosen, but the ISO is one setting that is manually set in all the exposure modes. A camera with a manual exposure mode option usually has this choice represented by an "M" somewhere on the camera exposure controls.

The photographer has complete control of the camera's shutter speed and f/stop settings because these exposure variables have to be manually set and/or changed by the photographer for each photograph.

Students learning how to make photographs with an SLR camera for the first time are frequently told to use only the manual exposure mode because this exposure mode makes them responsible for all the critical choices that have to be made when determining the proper exposure for each shot. It is also a good exposure mode to use when photographers wish to make decisions for themselves and not relinquish any creative control to a camera's computer. This is frequently the case with crime scene photographers.

Program Exposure Mode (P)

With the **Program Exposure Mode**, the camera sets both the f/stop and the shutter speed automatically on the basis of the amount of reflected light coming into the camera. A camera with a program exposure mode option usually has this choice represented by a "P" somewhere on the camera exposure controls.

In this mode, the photographer has no choice over the camera's creative controls. The camera works on preprogrammed algorithms, which select the exposure settings on the basis of the light being read by the meter.

The program exposure mode is sometimes referred to as the "dummy exposure mode." A photographer who cares only about a proper exposure can set the camera to program, aim, focus, and shoot. A proper exposure is almost always guaranteed. There is no creative photographer input.

The program exposure mode is not recommended for crime scene photography because, besides ensuring that there will be a proper exposure for all crime scene images, the crime scene photographer also needs to manage the area that will be in focus (depth of field). Sometimes, it is also important to manage the motion-stopping capability of fast shutter speeds. With most crime scene photography, it is important not only that there be a proper exposure but also that there is a proper exposure with the depth of field maximized. Or, it is important that there is a proper exposure and the motion of a moving subject is eliminated with an appropriately fast shutter speed. The use of the program exposure mode reduces everything to just one narrow concern: exposure. The need for a proper exposure is not to be denied. However, additional concerns are constantly tugging on the mind of the competent crime scene photographer.

The major complaint with the program exposure mode is that its computer algorithms seem to default to f/stops centering on f/4s and f/5.6s and shutter speeds centering around 1/250th of a second and 1/500th of a second. If the crime scene subject matter is static like most crime scene evidence, using faster-than-necessary shutter speeds and wider-than-necessary apertures wastes the full capabilities of the camera controls, just to ensure a proper exposure is obtained.

When the issue is training competent crime scene photographers, the program exposure mode is to be avoided. Proposing it as a viable exposure mode is tantamount to admitting either that (1) there is no one capable to teach crime scene photography properly to your crime scene photographers, or (2) you do not believe your crime scene photographers can understand more advanced crime scene photography methods. With any luck, neither condition exists within your agency.

This author did not place much value in the program exposure mode until he attended a training session held recently by the Evidence Photographers International Council (EPIC). Randy Anglin, from the Phoenix, Arizona, Police Department, referred to the program exposure mode as "patrol mode." He explained that when patrolling, he always kept his camera set to program mode. If he should respond to a scene that was still actively being worked, having the camera preset to program mode made the most sense. When things are hectic, having to "think" about exposures is a luxury an officer sometimes cannot afford. Being guaranteed a proper exposure was just one benefit. Having faster-than-normal shutter speeds also helps to freeze the motion of busy scenes. If victims are actively being treated, grabbing a few quick shots as they were originally encountered provides a great addition to a collection of static crime scene shots. If a victim is being wheeled on a gurney toward an ambulance, just grabbing the camera, and pointing and shooting may be all there

is time for. Once the melee has ended, Officer Anglin could return to the normal thoughtful crime scene photographer once more. His thoughts were right on point. Ever since this discussion, this author is forced to admit that the program exposure mode does have a definite use. Adding to your bag of tricks is something you should always be willing to do.

Aperture Priority Mode (A or Av)

In the **Aperture Priority Exposure Mode**, the photographer manually sets the f/stop desired, and the camera will automatically set the corresponding shutter speed required to properly expose the photograph for the reflected light coming into the camera, and the preselected f/stop.

A camera with an aperture priority exposure mode option usually has this choice represented by an "A" or "Av" somewhere on the camera exposure controls; the "Av" stands for aperture value. Care needs to be exercised with this mode, because if small apertures are selected to maximize the depth of field, and the lighting is inadequate, the result may be a shutter speed that is too slow for the camera to be hand-held, resulting in blurred photos if the photographer is not aware of the resulting slow shutter speed setting.

Would not a cure for slow shutter speeds be to just put the camera on a tripod and take most images that way? Actually, using a tripod would be enormously inconvenient for most crime scene photography. Certainly, many times a tripod cannot be avoided when taking crime scene images. But, because most crime scene images have to be taken rather quickly, there is just not enough time to take such images with the camera mounted on a tripod.

However, when you are in a situation in which using a tripod is recommended, using the aperture priority exposure mode is the ideal exposure mode. For instance, when you are taking a series of images of a bloody shoe print, once the ideal f/stop has been determined, setting the camera on a tripod will allow the camera to use any shutter speed for the series of photographs necessary to completely document the shoe print. This will enable you to vary the exposures without deviating from an optimal f/stop. This topic will be revisited in chapter "Focus, Depth of Field, and Lenses."

Shutter Priority Mode (S or Tv)

In shutter priority exposure mode, the photographer sets the shutter speed desired, and the camera will automatically set the corresponding f/stop required to properly expose the photograph on the basis of the light reflected into the camera, and the preselected f/stop.

A camera with a shutter priority exposure mode option usually has this choice represented by either an "S" or a "Tv" somewhere on the camera exposure controls; "Tv" stands for time value. The shutter priority exposure mode is **very useful** because it basically does exactly what the manual exposure mode would do, only faster. The photographer concerned about depth of field as well as a proper exposure will usually select the slowest hand-holdable shutter speed, usually 1/60th of a second when a 50 mm lens is being used. The corresponding aperture is then usually the best to maximize depth of field. In the shutter priority exposure mode, with the camera set to 1/60th, the camera automatically sets this same aperture. The camera just does it faster and without manual adjustments.

Although camera settings that make the photographer responsible for every camera variable are normally recommended, the shutter priority exposure mode efficiently arrives at the exact same position as the manual exposure mode. It does not reduce the photographer's responsibilities; it makes the process more efficient.

BRACKETING

Manual Exposure Mode Bracketing

In the manual exposure mode, the photographer sets both the f/stop and the shutter speed for every photograph. When bracketing, the question is whether to alter the f/stop, the shutter speed or the ISO to make an exposure change.

With a digital camera, ISOs can be changed as easily as f/stops or shutter speeds. This option represents a great advantage when determining exposures is concerned.

When you are **Bracketing for an underexposure**, remember the Cardinal Rule to maximize depth of field: if the minimum f/stop has not already been used, bracket by decreasing the aperture size. Making the aperture smaller not only results in a dimmer photograph than the first photograph but also increases the depth of field. For example, if the original exposure combination was made up of 100 ISO, a shutter speed of 1/60th of a second, and f/11, the proper way to achieve a –1 exposure would be to change the f/stop to f/16. If the smallest aperture of the camera has already been chosen, then simply use a

faster shutter speed or a slower ISO. If an f/22 was being used for the original image, change the shutter speed from 1/60th of a second to 1/125th of a second. The faster shutter speed is 1 stop dimmer and can also be used when hand-holding a 50 mm lens. Or, you can also change the ISO from 100, or instance, to 50, if you have it. Changing to ISO 50, however, sometimes requires going into the camera's menu, which is not as easy as just changing the shutter speed.

When you are **Bracketing for an overexposure**, presuming you are already using the slowest hand-holdable shutter speed for a 50 mm lens, which is 1/60th of a second, the choices are limited to opening the aperture or going to a faster ISO. In this case, using a slower shutter speed like 1/30th of a second may result in camera movement during the exposure and blurring of the image. For example, if the original exposure were 100 ISO with a 1/60th second shutter speed with an f/11, one option to achieve a +1 exposure would be to reset the f/stop to f/8. The other option would be to reset the ISO from 100 to 200.

If the original f/stop used was f/8, you might think that using f/5.6 would be a natural choice. However, think back to the reciprocal shutter speeds and f/stops previously recommended. You will recall that 1/60th of a second was the primary shutter speed recommended for most crime scene photographs. You will also recall that the small apertures f/22, f/16, f/11, and f/8 were the best f/stops to ensure an adequate depth of field was achieved. If you find you are about to use an f/5.6 during crime scene photography, it is strongly urged that you consider three other options before actually using that aperture. This can be considered a new Rule of Thumb.

RULE OF THUMB 4.8

Before using an f/5.6, or wider aperture, for a crime scene photograph, consider these options:

1. Use electronic flash. The additional light from the flash will certainly allow the use of smaller apertures, which in turn will provide a better depth of field.
2. Use a tripod. Putting the camera on a tripod will allow the use of longer shutter speeds without the risk of blur, and the use of longer shutter speeds will also allow smaller apertures to be used, which will provide a better depth of field.
3. With a digital camera, reset the ISO to the next faster ISO setting. That will enable the use of both a 1/60 and an f/8, with the ISO setting used to create the +1 exposure.

Automatic Exposure Mode Bracketing

In the aperture priority exposure mode, the photographer has control of only the f/stop selections; in the shutter priority exposure mode, the photographer has control of only the shutter speed selections. What if you are using one of these exposure modes and would like to bracket several shots? If all you can control is the f/stop, does changing the f/stop selection in the aperture priority exposure mode result in a change of exposures? If all you can control is shutter speed, does changing the shutter speed in the shutter priority exposure mode result in an exposure change? In both cases, the answer is "no."

In the automatic exposure modes, the camera automatically compensates for an adjustment to either the f/stops or shutter speeds so that another proper exposure is still achieved: A reciprocal exposure is the result.

In the shutter priority exposure mode, if the initial shutter speed is 1/60th of a second, will change the shutter speed to 1/125th of a second result in a –1 exposure? No.

If the shutter speed is changed, the camera's computer will seek an f/stop that will provide a proper exposure for the newly selected shutter speed. For example, if the original shutter speed was 1/60th of a second and the scene lighting allowed the camera's computer to automatically select an f/11 to properly expose that scene, what would happen if the photographer selected a 1/125th of a second shutter speed instead? The camera's computer would select an f/stop that is a reciprocal exposure for the 1/60/f/11 exposure combination. In this case, the new reciprocal exposure would be 1/125 and f/8. Switching from 1/60th of a second to 1/125th of a second would not result in a –1 bracket. It would result in another reciprocal exposure that was the same as the original exposure.

In the aperture priority exposure mode, if the initial f/stop is f/11, will change the f/stop to f/16 result in a –1 exposure? No.

If the aperture is changed, the camera's computer will seek a shutter speed that will provide a proper exposure for the newly selected f/stop. For example, if the original shutter speed was f/11 and the scene lighting allowed the camera's computer to automatically select a 1/125th of a second shutter speed to properly expose the scene, what would happen if the photographer selected an f/16 instead? The camera's computer would select a shutter speed that is a reciprocal exposure for the 1/125 and f/16 exposure combination. In this case, the new reciprocal exposure would be f/16 and



FIGURE 4.57
Exposure compensation button: (+/–).
Courtesy of Ron Taniwaki, Nikon Forensic Services.

1/60th of a second. Switching from f/11 to f/16 would not result in a –1 bracket. It would result in another reciprocal exposure that was the same as the original exposure.

So, how is bracketing achieved in the automatic exposure modes?

Many cameras that have automatic exposure modes also have an **exposure compensation dial**. Those cameras that do not have an exposure compensation **dial** have **buttons** or other menu choices to allow the photographer the ability to vary automatic exposure choices.

Fig. 4.57 shows an exposure compensation button (+/–) on a new digital Nikon SLR. Pushing it takes you to the exposure compensation menu.

If you were in either the shutter priority exposure mode or the aperture priority exposure mode and you just completed taking a shot at what you determined to be an "optimal" exposure, how do you bracket? For a +1 exposure, rotate the exposure compensation dial to the +1 mark and take a second exposure. For a –1 bracket, rotate the dial to the –1 mark and take a third exposure.

After this series of brackets, it is critical to remember to **reset** the exposure compensation dial back to the "0" position. If you forget to do this, all the remainder of your exposures will be either overexposed or underexposed, depending on the last exposure compensation dial setting.

If the proper exposure triangle has only four variables—and it does—how can the exposure compensation dial effect a change in exposure?

The exposure compensation dial actually resets the ISO speed to "fool" the camera so an exposure change will be made by the camera. An example is the best way to explain this.

A photographer is using the shutter priority exposure mode with the camera set to 100 ISO and the shutter speed set to 1/60th of a second. When a meter reading was taken by depressing the shutter button halfway, the camera's computer determined the proper f/stop for the reflectivity of the scene in question was f/16. This was the first exposure. Wanting to bracket for a **+1**, the photographer rotated the exposure compensation dial to **+1** and took the second shot. How does this force the camera's computer to set an exposure combination that results in a brighter exposure? When the exposure compensation dial is set to **+1**, the ISO setting is actually reset to 50 ISO; 50 ISO film is a "slower" ISO that is less sensitive to light, so it needs more light for a proper exposure. How much more? The 50 ISO would need precisely 1 stop more light than ISO 100 would. If 100 ISO needed a 1/60th of a second shutter speed with an f/16, 50 ISO would need 1/60th of a second shutter speed and f/11 as the aperture. Changing exposure from f/16 to f/11 results in a **+1** exposure change. Even though the camera now thinks it is set at 50 ISO, it is actually still set at 100 ISO. The net result: a **+1** exposure.

Another example, which starts out the same: A photographer is using shutter priority exposure mode, with the camera set to 100 ISO and the shutter speed set to 1/60th of a second. When a meter reading was taken by depressing the shutter button halfway, the camera's computer determined the proper f/stop for the reflectivity of the scene in question was

f/16. This was the first exposure. Wanting to bracket for a **–1**, the photographer rotated the exposure compensation dial to **–1** and took the second shot. How does this force the camera's computer to set an exposure combination that results in a dimmer exposure? When the exposure compensation dial is set to **–1**, the ISO setting is actually reset to 200 ISO; 200 ISO is a "faster" setting that is more sensitive to light, so it needs less light for a proper exposure. How much less? The 200 ISO would need precisely 1 stop less light than ISO 100. If 100 ISO needed a 1/60th of a second shutter speed with an f/16, 200 ISO would need 1/60th of a second shutter speed and f/22 as the aperture. Changing exposure from f/16 to f/22 results in a **–1** exposure change. Although the camera now thinks it is set at 200 ISO, it is actually still set at 100 ISO. The net result: a **–1** exposure.

To achieve a true change in the exposure, you actually need to fool the camera about the ISO that has been loaded into the camera.

In the aperture priority exposure mode, the photographer selects the aperture. Changing the exposure compensation dial to a plus or minus number forces the camera to alter the shutter speeds. An example is helpful here also.

A photographer is using aperture priority exposure mode, with the camera set at 100 ISO and the aperture set to f/16. When a meter reading was taken by depressing the shutter button halfway, the camera's computer determined the proper shutter speed for the reflectivity of scene in question was 1/125th of a second. This was the first exposure. Wanting to bracket for a **+1**, the photographer rotated the exposure compensation dial to **+1** and took the second shot. How does this force the camera's computer to set an exposure combination that results in a brighter exposure? When the exposure compensation dial is set to **+1**, the ISO setting is actually reset to 50 ISO; 50 ISO is "slower" and is less sensitive to light, so it needs more light for a proper exposure. How much more? The 50 ISO would need precisely 1 stop more light than ISO 100 would. If 100 ISO needed an f/16 with a 1/125th of a second shutter speed, 50 ISO would need f/16 and 1/60th of a second shutter speed. Changing exposure from 1/125 to 1/60 results in a **+1** exposure change. Even though the camera now thinks it is set at 50 ISO, it is actually still set to 100 ISO. The net result: a **+1** exposure.

In the preceding example, had the original shutter speed been 1/60th of a second, selecting a +1 on the exposure compensation dial would have forced the camera's computer to change the shutter speed to 1/30th of a second. This, of course, is a shutter speed that is too slow when using a 50 mm lens. Camera shake would almost guarantee blur in the photograph. This is another reason that the aperture priority exposure mode should only be used with caution.

The exposure compensation dial should only be used for bracketing when one of the automatic exposure modes is in use. These modes are, again, the aperture priority exposure mode, the shutter priority exposure mode, and the program exposure mode. The exposure compensation dial does ***not*** produce a bracket when the manual exposure mode is in use. In the manual exposure mode, bracketing is accomplished by manually altering the shutter speed or the aperture.

Flash Bracketing

It is also possible to bracket for a brighter or dimmer image when an electronic flash is used. This will be explained more fully in the chapter "Electronic Flash." However, for the purposes of this chapter, be aware that it is often possible to set the flash so that it emits either more or less light than usual. Therefore, the original shutter speed and f/stop can be maintained, and subsequent exposures can be altered merely by altering the flash intensity.

THE f/16 SUNNY DAY RULE

If you looked on the inside surface of a box of film (if you can still find any), after you take out the film canister, you will frequently find film manufacturer recommendations for proper exposures when using that particular film under different outdoor light levels.

Learning the **f/16 Sunny Day Rule,** and its corollaries, allows one to frequently determine the entire exposure combination required for many scenes just by noting the lighting at the scene. You can then accurately anticipate what exposure combination will be required. I joke to my students that I have the ability to "smell the light" and just by looking at a scene I can predict what ISO, shutter speed, and f/stop will be optimal for that scene. This makes beginning photography students very nervous. However, when you think about it just a bit, you may realize that you, too, have this power. Actually, though, it is just the application of applying the f/16 sunny day rule.

The f/16 sunny day rule recommends both an f/stop setting and a corresponding shutter speed for most outdoor photographic situations. The f/16 sunny day rule, however, is just a way to determine a "ball park" **exposure** combination for different lighting conditions. It is not the best exposure combination if you wish both a proper exposure and you also want to maximize the depth of field. In other words, the net result is just one reciprocal exposure, and it is up to you to choose among the other possible reciprocal exposures when depth of field is also important.

An f/16 Day

At midday, on a bright sunny day, when there are crisp, distinct, well-defined shadows (see the left image of Fig. 4.58), use an f/16 and convert the ISO speed to the shutter speed. Notice that in the left image of Fig. 4.58 you can count the extended fingers. If there is not an exact shutter speed to approximate the ISO, go to the next fastest shutter speed. So, if you are using 100 ISO, convert to a shutter speed of 1/125th of a second. If you are using 400 ISO speed film, convert to 1/1500th of a second shutter speed. However, if it is midday on a bright sunny day, at this point it is hoped you would only consider the ISO 100 speed film option. Remember the suggested ISOs for different times of day and different lighting?

If the f/16 sunny day rule suggests using an f/16 and a 1/125th of a second shutter speed with 100 ISO, is there a **better** reciprocal shutter speed? Yes. Changing the shutter speed to 1/60th of a second would allow the use of an f/22 for the same scene, which provides the same reciprocal exposure and provides a better depth of field.

An f/11 Day

On a bright, but hazy, day when the shadows produced are indistinct or produce what can be termed as "soft" shadows (see the right side of Fig. 4.58), use an f/11 and convert the ISO speed to the shutter speed. In this case, the shadows present are ill defined. The shadows form vague shapes, and any distinct details around the periphery of the shadow cannot be determined. Notice that in the right side of Fig. 4.58 one cannot count the extended fingers. With 100 ISO, the exposure recommendation would be f/11 and 1/125th of a second shutter speed. Is there a better reciprocal exposure? Yes. Changing the shutter speed to 1/60th of a second would allow the f/stop to be changed to f/16, and this combination is the same exposure with a better depth of field.

An f/8 Day

On a bright but cloudy day, there may be plenty of outdoor light, but there will not be any shadows at all. The right side of Fig. 4.59 is an example of an "f/8 kind of day." The left side shows an "f/16 kind of day." On a cloudy day with no shadows, use an f/8, and convert the ISO film speed to the shutter speed. This results in an f/8 and a 1/125th of a second shutter speed. Although a proper exposure for the scene, a better reciprocal exposure would be f/11 and 1/60th of a second shutter speed, which provides a better depth of field.



FIGURE 4.58
Left: An f/16 sunny day shadow. *(Courtesy of A. Lowcher, GWU MS student.)* Right: An f/11 "soft" shadow. *(Courtesy of L.Pacheco, GWU MS student.)*



FIGURE 4.59
"Hard" shadow and no shadow from an overcast day.
Courtesy of Dale Rio, GWU MS student.

An f/5.6 Day

The f/8, "cloudless" kind of day has many variations, so there can be multiple days without clouds which require different exposures. Sometimes an exposure using an f/8 will be required, and sometimes an f/5.6 will be required. When in doubt, try both exposures.

An overcast day can still produce bright lighting outdoors but will seldom produce any shadows. Another situation for this exposure category would be on a sunny day, when the sun is blocked from the area of interest by a building or something similar (see Fig. 4.60). In this case, the item of evidence would be "in" a shadow, but if you stood in the same location as the evidence and looked up, there would be blue sky above you. Blue sky itself is quite bright. Fig. 4.60 shows the house blocking the sun in front of the house. If there was evidence accidently dropped there by a fleeing burglar, that evidence would probably require either an f/8 to properly expose it and convert the ISO film speed to the shutter speed.

The f/16 sunny day rule variations, however, are only **exposure** recommendations. And, they are not concerned with depth of field. Therefore, it would be appropriate to change these exposure combinations to a reciprocal exposure variant which provides both a proper exposure **and** a better depth of field.

The f/16 sunny day rule, and these variants, suggests exposure recommendations that will be close enough to produce an exposure that will be printable. Because they are just guidelines, they should not be used when the reflective light meter is working. The reflective light meter will always be more exact.

The f/16 sunny day rule recommends that the ISO being used be converted to the shutter speed. Therefore, ISO 100 becomes 1/125th; ISO 200 becomes 1/250th; and ISO 400 becomes 1/500th. These are, of course, full shutter speed changes. As mentioned previously, some cameras allow you to select shutter speeds in 1/2-stop or 1/3-stop increments. If these are possible, the closest incremental shutter speed to the film speed being used should be selected. The shutter speed selected should be as "fast" or "faster" than the shutter speed number. In other words, if you have 400 ISO currently selected, and a shutter speed of 1/350th of a second is available, you should select 1/500th of a second shutter speed even though 1/350 is actually closer to 1/400th. The 1/500th shutter speed is "faster" than the 1/350th. This is part of the f/16 sunny day rule.

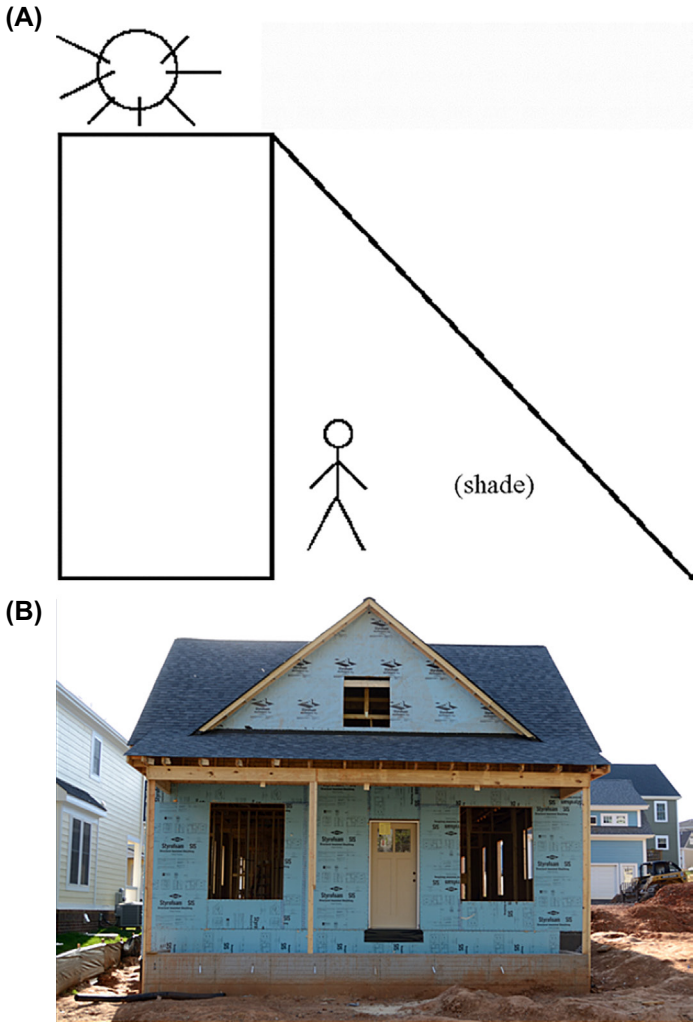


FIGURE 4.60
(A) An "open" shade situation. (B) "Open" shade in the front yard. *(Courtesy of K. Mentore, GWU MS student.)*

It is important to repeat that the f/16 sunny day rule is just a recommendation for an exposure setting, just as the camera's meter reading is merely one of many reciprocal exposure possibilities. The f/16 sunny day rule does not have anything to do with a crime scene photographer's additional desire to maximize the depth of field; it is just an exposure recommendation. Therefore, once an exposure combination has been determined using the rule, the photographer then has to ask whether that exposure recommendation is the most efficient reciprocal exposure to also maximize the depth of field. An exposure adjustment will almost always be necessary.

UV/Haze/1A/Skylight Filters

UV/Haze/1A/Skylight filters have two common uses, as described in the following sections.

LENS PROTECTION

Filters are inexpensive insurance for all the lenses you own. As you use and handle your camera, it swings from a strap around your neck or is otherwise held at the end of your arm. This increases the potential for the camera to frequently bump into a variety of other objects in your environment. Some of these contacts may scratch, break, or dent the front of the lens, requiring an expensive repair or replacement. Having a relatively inexpensive filter mounted on each lens protects the front of those expensive lenses. Replacing the filter that gets scratched, dented, or broken is much less painful than replacing the lens itself. Therefore, an inexpensive filter, for example, a **UV Filter**, should be placed on each lens you own (Fig. 4.61B).



FIGURE 4.61
(A) Dent to UV filter instead of the lens itself. (B) UV filter.

Fig. 4.61A, shows a dent to the UV filter attached to the lens. Had this been a dent to the lens itself, it would be impossible to use any filter with it because no filters would be able to screw onto the filter threads of the lens. Now, because only the outer filter is dented, if the photographer wished to use any other filter, all that would have to be done is to unscrew the dented filter. Replacing this dented filter is not necessary. It is still serving its primary purpose of protecting the lens.

Put a filter on each lens you own.

FILTERING EXCESSIVE BLUE FROM THE SKY

Digital sensors are very sensitive to both the UV and blue light of the sky. Without a filter, the sky will normally photograph lighter than you remember seeing it. Because sensors are so sensitive to this light, the sky is frequently overexposed in photographs. For the sky to record realistically in photographs, it is recommended to use one of several filters. Four filters have basically the same effect on the sky, without significantly altering the way other aspects of the scene will appear. These four filters are the UV filter, the Haze filter, the 1A filter, and the Skylight filter. Their effect is to have the sky record more correctly on the digital sensor. They do this by filtering out some of this light to avoid overexposures. They do not reduce the other light coming through the lens in any significant way, so exposure compensations are not necessary.

These four filters appear to be clear filters, not showing either a colored tint or neutral tinting like polarizer filters and ND filters. The Fig. 4.61B demonstrates this. The blue cloth background appears the same either viewed directly or viewed through the filter.

When you are composing on scenic views and vast panoramas, these filters will assist in keeping the haze effect from long expanses of air, with the particulate matter suspended in the air, from ruining photographs. Haze can manifest itself as misty vapors. Residents of smog-polluted Los Angeles, California, and Phoenix, Arizona, have an innate understanding of particulates in the air.

In normal crime scene photography, addressing the haze effect is not normally a concern. If, however, your task is to document a crime scene with aerial photography, haze may become a problem, depending on the height of the aircraft. By use of a haze filter, you will be able to "shoot through the haze" to visualize the ground structures better.

The Polarizer Filter

A polarizer filter can be a very useful tool for the crime scene photographer.

Although it is not obvious at first glance, the polarizer filter is usually made up of two parts, unlike other filters. It has filter threads, like other filters, which screw normally onto the lens. Once secure on the lens, however, the outer part, which holds the polarizer filter itself, can still be rotated.

A word of caution is necessary here. The polarizer filter screws onto the lens like any other filter. If you are looking down on the camera with the lens pointed at the ceiling, the polarizer filter would screw on by rotating it in a clockwise direction. All filters should be screwed on with the camera in this position. With the lens aimed at the ceiling, you can actually let go of the filter before it has been completely screwed on, and the filter will remain sitting on the lens. If your habit is to screw on filters with the lens aimed horizontal to the ground, it would be possible to mistakenly believe the filter is properly screwed onto the lens. If you then let go of a filter not properly screwed onto the lens, it can fall to the ground and break.

This becomes a new Rule of Thumb.

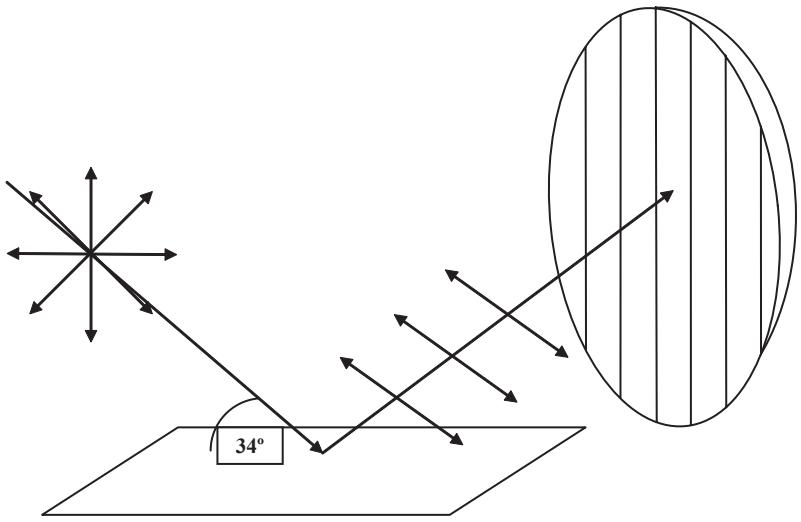
RULE OF THUMB 4.9

Always screw filters onto the lens when the lens is aimed at the ceiling or straight up. This reduces the chances of dropping the filter.

Once the polarizer filter is properly screwed onto the lens, the outer part can be rotated to reduce or eliminate reflections and glare on a variety of surfaces. It is extremely important that the filter be rotated without unscrewing the filter from the lens. This filter rotation is done while holding the camera normally and looking through the viewfinder. The filter rotation must be done in a **counterclockwise** direction, with the camera held normally. If the filter rotation is done in a clockwise direction, you may be inadvertently unscrewing the filter at the same time as you are rotating the filter. Too many polarizer filter have been dropped because of this. Always rotate the polarizer filter **counterclockwise** when holding the camera viewing the scene.

Reflection Elimination

Notice Fig. 4.62 shows the polarizer filter with vertical lines running through the filter. Such lines cannot actually be seen when looking through the filter. They are placed there to be a visual explanation of the polarizer filter's ability to filter out, or block, polarized light. On the figure, because the surface reflecting the polarized light is the ground, the polarized light is reflected from it in a horizontal, rather than a vertical, plane, which is represented by the three diagonal lines coming from the surface toward the filter. Had the light reflected from a building window, the polarized



Unpolarized light vibrates in all directions. When striking water or glass, the light can become polarized in one direction, and show reflections. The reflections can be eliminated by a polarizer filter which absorbs/blocks the polarized light.

FIGURE 4.62
Graphic to explain how a polarizer filter blocks polarized light.

light would have a vertical orientation. In either case, the photographer will be able to see the effect of rotating the filter while looking through the viewfinder. When the filter is rotated so polarized light is blocked by the filter, reflections will be either drastically reduced or totally eliminated. Continuing to rotate the filter would align the filter so the polarized light can come through the filter, and all the reflections again become visible.

Figs. 4.63 and 4.64 show images where the photographers positioned themselves to have a 34-degree angle that the light is striking the surface and reflecting from the surface, which is the optimal angle of view of a surface with reflections on it when you want the polarizer filter to eliminate those reflections. As you deviate from that 34-degree viewpoint, the polarizer filter will become more and more ineffective. The crime scene photographer can do nothing about this. The physics of polarized light just has to be accepted. Some solutions, however, exist to address the problem of distracting reflections.

To maximize the elimination of reflections from glass and water, follow this three-step procedure:

1. Approximate what you feel is a 34-degree angle to the surface with reflections on it.
2. Put the polarizer filter on your lens, and rotate the outer element until the maximum amount of reflections are eliminated. If you rotate the outer element beyond the optimal position, the reflections will begin to return. Keep rotating the outer element until the reflections are again diminished almost completely.

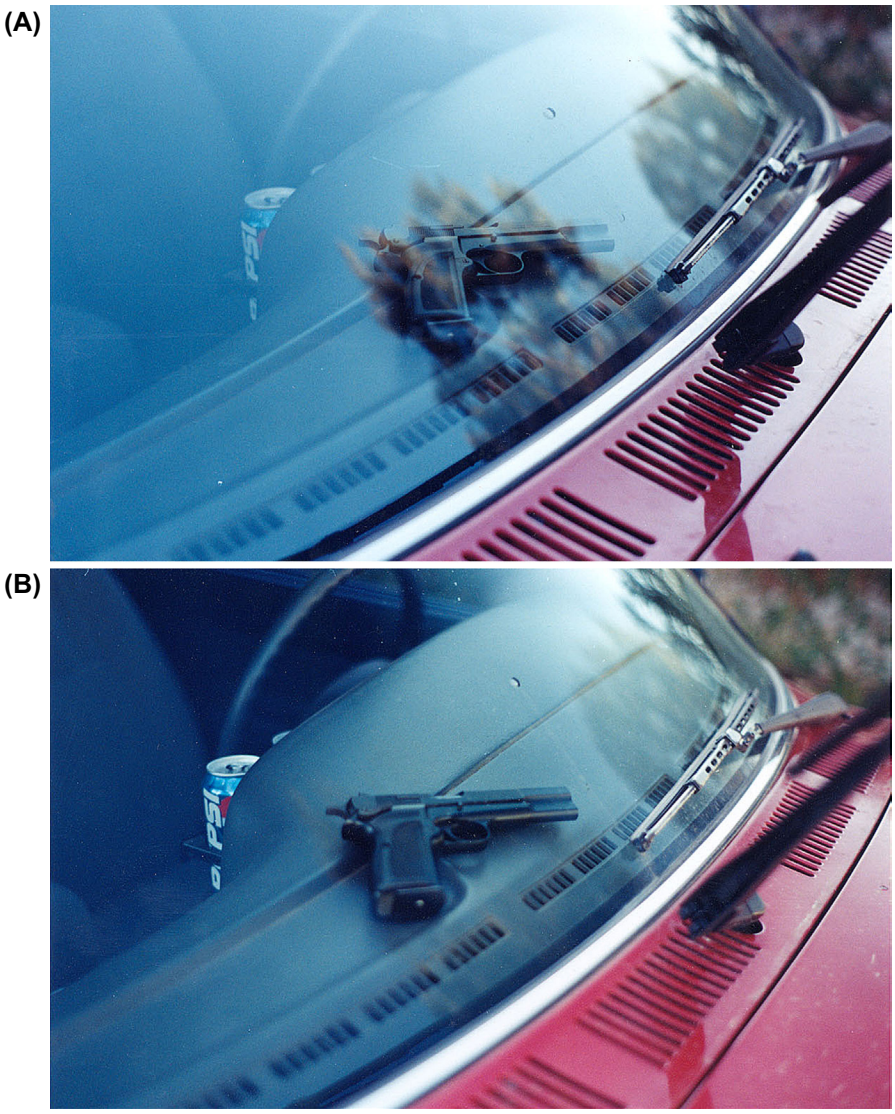


FIGURE 4.63
(A) No polarizer filter used. (B) Polarizer filter used.



FIGURE 4.64
(A) Polarizer filter not used. (B) Polarizer filter used.
Courtesy of M. Ward, GWU MDS student.

3a. At times, the reflection has not completely disappeared, which may be merely a function of your not having correctly assumed a 34-degree-angled view of the surface in question. If the surface is a vertical sheet of glass, it is recommended that you "test" your approximation of a 34-degree angle by **leaning to the left and to the right** while looking through the viewfinder. By doing so, you may achieve a view closer to the magic 34-degree angle. As you do this, you may see the reflection become more prominent when leaning in one direction and less prominent when leaning in the other direction. Move in the direction that eliminates more of the reflection.

3b. If the reflection is coming from water, that surface is horizontal. To "test" your success of having successfully found the correct 34-degree angle, move **closer** to the surface or **back away** from it while looking through the viewfinder. You may see the reflection become more prominent one way and less prominent as you move the other way. Move in the direction that eliminates more of the reflection.

The polarizer filter will not remove the reflection of the sun itself. If the sun is currently creating an unwanted reflection, say, for instance, it is making a reflection on the sheet metal of a car, the only way to eliminate it is to find a different viewpoint of the surface.

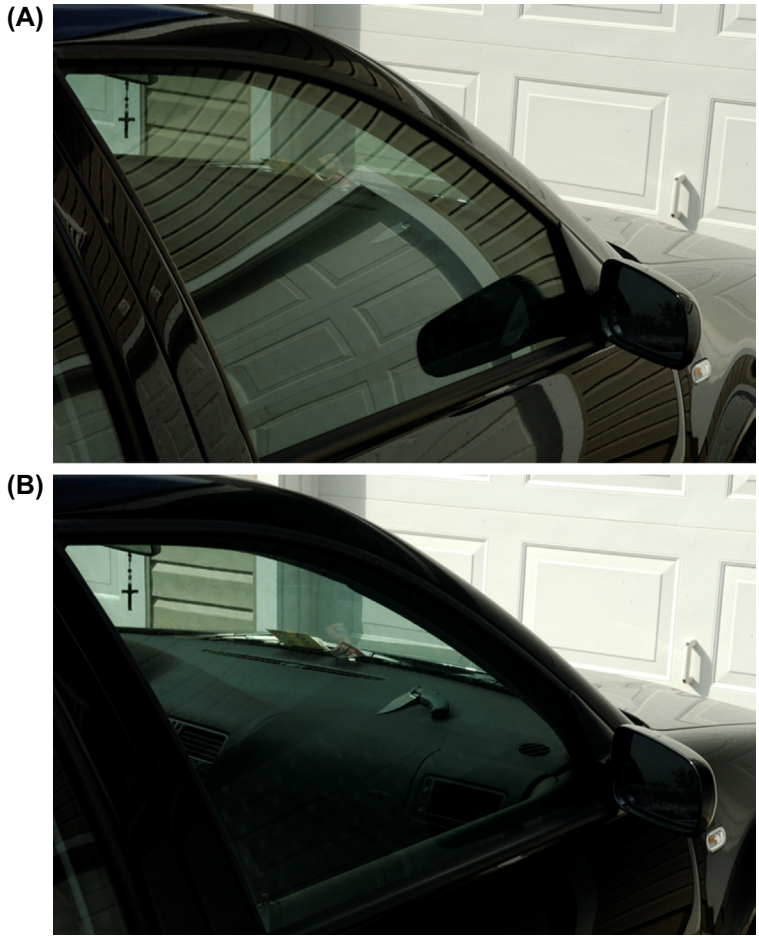


FIGURE 4.65
(A) Polarizer filter not used. (B) Polarizer filter used to eliminate the reflection.
Courtesy of M. Ward, GWU MDS student.

When the polarizer filter has eliminated all the polarizing light reflected from a surface, the result is a 1.3- to 2-stop light reduction the camera is now receiving. In Fig. 4.65A shows the window reflection making it difficult to see the knife on the dashboard; the Fig. 4.65B shows the reflection successfully eliminated by the use of the polarizer filter. However, the inside of the vehicle looks a bit underexposed. It is here that we have to remember that a polarizer filter not only reduces or eliminates reflections but also blocks 1.3–2 stops of light. If you are using a reflective light meter, it is important to remember to **remeter** the scene **after** the polarizer filter has been rotated for its optimal effect. The meter will then ensure the scene is not underexposed. The Fig. 4.66A is the same as the Fig. 4.65B. Realizing it is now necessary to remeter the scene, with the polarizer filter optimally eliminating reflections, results in a new exposure: the Fig. 4.66B.

Enriching Color Saturation

By eliminating polarized light, polarizing filters can also improve the colors in many photographs. Strong sunlight often produces a glare that is sometimes perceptible to the eye. When you eliminate this glare, the color saturation of a photograph can be improved. When color accuracy is critical, as when you are trying to document the exact color of a paint transfer in a fatal hit-and-run accident, this aspect of the polarizer can be an immense benefit.

Skid Marks

A polarizer can remove the glare on the pavement at an accident scene, making the skid marks present at the scene more obvious (see Fig. 4.67). Up to 10% of the total length of a skid mark may be a "shadow" mark. This is a less obvious tire mark left by the tire as it was slowing before the tires became totally locked. At times, even this "shadow" mark can be visualized with a polarizer filter. It is important that the driver get "full credit" for the speed he or she was actually driving, and being able to document the full length of the skid mark is one way of doing this.

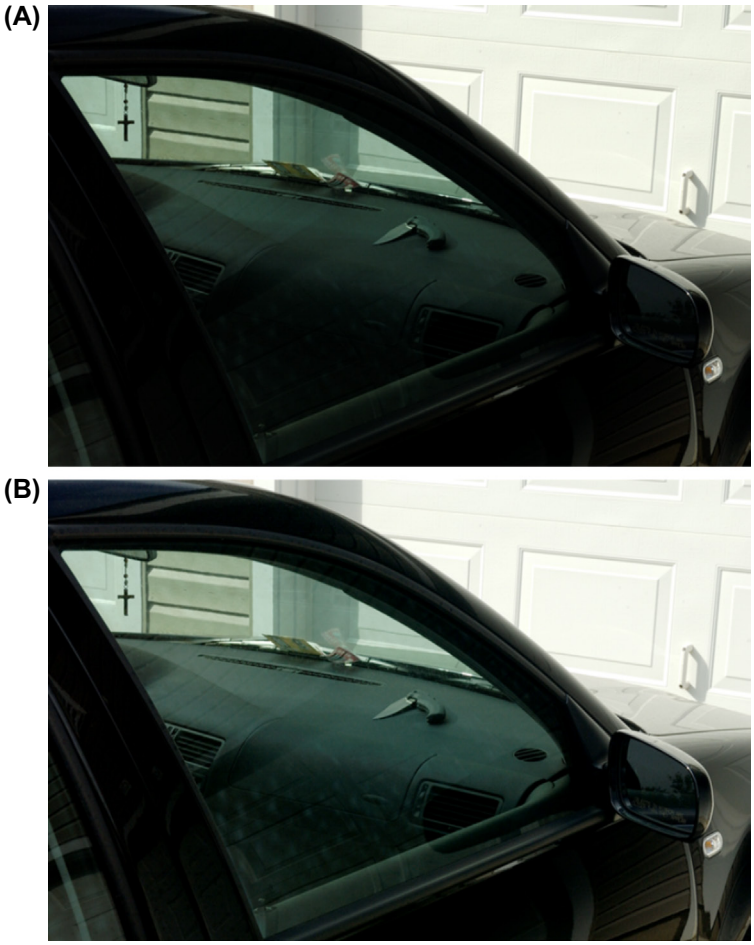


FIGURE 4.66
(A) No exposure change for the top image. (B) a +1.5 exposure change produces the bottom image.
Courtesy of M. Ward, GWU MDS student.



FIGURE 4.67
The polarizer filter on the right image shows longer skid marks.
Courtesy of J. Veltri, GWU MFS student.

The effect is visible while looking through the viewfinder while rotating the outer element of the polarizer filter. For this effect, the polarizer should be used at approximately a 34-degree viewpoint to the surface of the pavement. It is recommended you view the skid marks from both ends. The polarizer filter may be more effective from one direction than another.

A polarizer filter should be considered essential equipment for accident scene photographers.

1.3–2 Stops Less Light

As mentioned previously, the polarizer filter appears much like a ND filter: it is shaded a tone of *gray* (see Fig. 4.68). This suggests that it will also filter "normal" light coming through it, which is true. When set to allow polarized light to come through the filter, the polarizer filter will still filter out approximately 1.3 stops of "normal" light. As the outer filter element is rotated, more polarized light is also absorbed by the filter. When set to block all the polarized light, the total light reduction is approximately 2 stops.

Linear and Circular Polarizer Filters

When shopping for a polarizer filter, you will notice there are both linear and circular polarizer filters. Linear polarizer filters are designed to work with manual focus lenses and are usually less expensive. Circular polarizer filters should be obtained for use with lenses with autofocus capability.

The chapter on "Ultraviolet, Infrared, and Fluorescence" will be devoted to more exotic filters. The UV filter mentioned in this chapter blocks UV light. Another kind of UV filter transmits UV light and blocks all visible light, which is necessary when photographing evidence only "visible" in the UV light range. When photographing evidence that is fluorescent, you will need to use either a yellow, orange, or red filter on the lens, which will enable the fluorescence of the evidence to be photographed, while the stimulating light of a laser or ALS is blocked by one of these filters. An IR filter blocks visible light while transmitting IR light. This filter is used when photographing evidence only "visible" in the IR light range.

THE EYE CUP COVER

At the beginning of the chapter, it was explained how the light coming in through the lens serves double duty. A mirror reflects that light up into the pentaprism, where other mirrors allowed the photographer to see the image coming in through the lens. Once this mirror flips up, when the shutter button was depressed, this same light could travel straight back to strike the sensor. If light can travel from the lens to the viewfinder, the reverse is also possible.

The lens was removed from the camera in Fig. 4.69, and the photographer is now looking into the camera from where the lens is normally attached. The back of the camera is facing a window in the author's office, making it now possible to see the image of a person walking on the sidewalk across from the author's office. The light has entered the viewfinder, is bounced around by several mirrors in the pentaprism, and you can see the result at the front of the camera. Without a lens to focus the image more clearly, everything is a bit fuzzy. But, certainly, light can get into the camera from two directions.



FIGURE 4.68
Polarizer filter: darkens the background cloth.

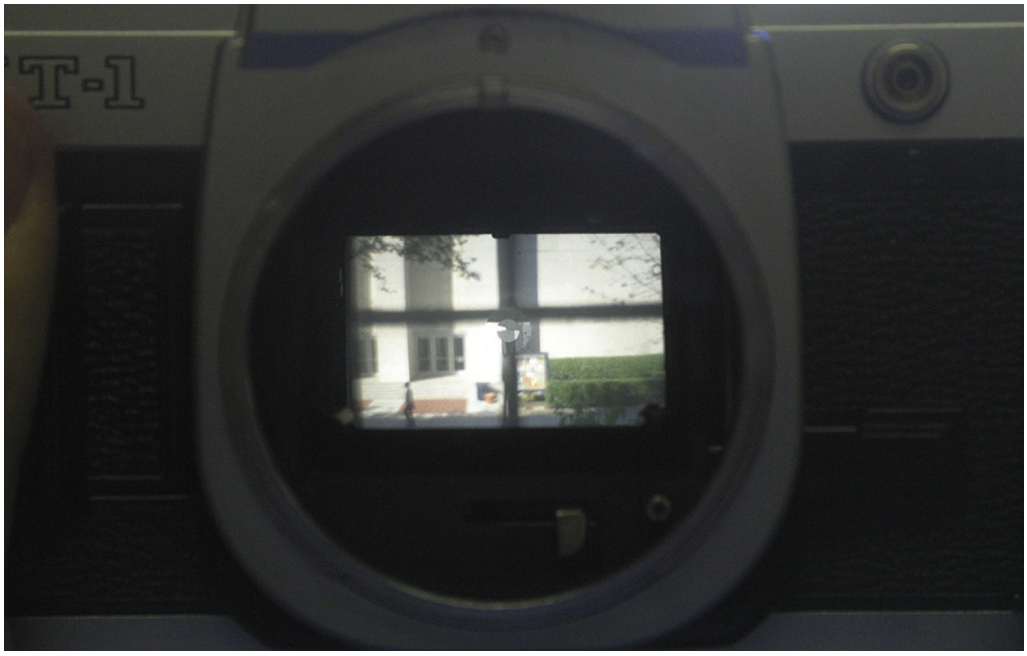


FIGURE 4.69
View of light coming in through the viewfinder.

It is, therefore, appropriate that this chapter on exposure ends by mentioning that light entering the camera through the viewfinder can have an effect on the exposure for any photograph. Normally, when your eye is pressed up close to the viewfinder, this possibility is moot. Stray light finding its way around your head to sneak between your eye and the eye cup of the camera and eventually entering the camera is so minimal that it is not a realistic concern. However, many times your eye is not near the viewfinder when an image is captured.

If you are taking a series of bracketed photographs of evidence, the camera is normally on a tripod, with the film plane parallel to the evidence. You have already determined the exposure for the first photograph in the series of brackets, and the camera has been focused. Using a shutter release cable, you take multiple shots, with only the f/stop usually needing to be altered. It is not necessary to look through the viewfinder to do this. Even if the camera has autobracketing capability and will take three different exposures with just one push of the shutter release cable button, you are not leaning toward the camera to look through the viewfinder. After all, once the shutter is activated, the mirror flips up, and nothing can be seen through the viewfinder anyway.

Also, if you are about to do a painting with light sequence outdoors at night, trying to properly expose a large dim crime scene with multiple flashes, the camera is again set up as before, without an eye pressed up against the viewfinder. This technique will be fully described in chapter "Electronic Flash."

In these cases, stray light coming into the camera through the viewfinder can affect the exposure of the camera. Camera manufacturers also know this and usually provide a "tool" to avoid this problem when you first buy a camera. This eye cup cover is designed to be inserted in slots provided over the viewfinder (Fig. 4.70). Most cameras sold also come with a camera strap. On many camera straps, there is an eye cup cover, see Fig. 4.71. The eye cup cover may also be in the box of camera accessories. The Fig. 4.71A shows the eye cup cover on the camera strap, a handy place to keep it, and the Fig. 4.71B shows the eye cup cover placed over the eye cup of the viewfinder. Many people do not even notice it. There is not much to notice: usually just two projections that will eventually slide over the left and right edges of the eye cup frame. Many newer cameras, including the Nikon shown in Fig. 4.72, feature built-in sliding viewfinder covers.

If you find yourself in a situation in which you are about to depress the shutter by any means and your eye will not be pressed up to the viewfinder, use the eye cup cover on your camera strap or a built-in viewfinder cover to avoid any exposure irregularities. The result of any extra light influencing the exposure for a particular shot is usually an underexposure. When more light is noticed by the reflective light meter, it adds this to the sum of the light it receives through the lens and will provide a proper exposure for all the light it has noticed. If the "scene" is brighter, the meter will recommend an exposure combination that uses a smaller aperture. A smaller aperture results in an underexposure.

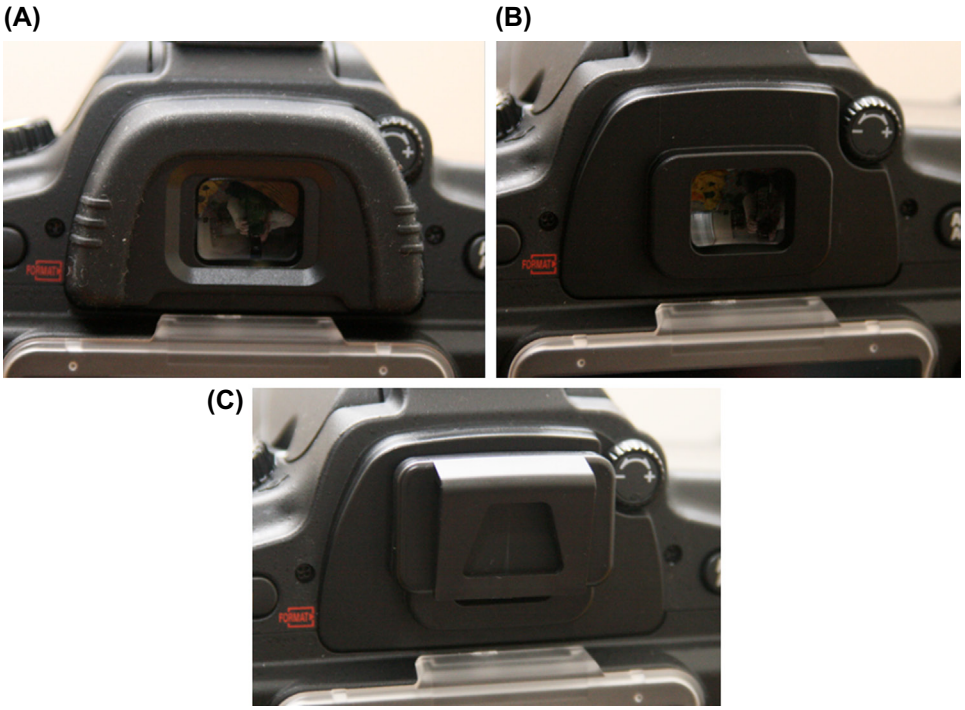


FIGURE 4.70
(A) Viewfinder with rubber guard around it. (B) Rubber guard removed. (C) Eye cup cover over viewfinder.

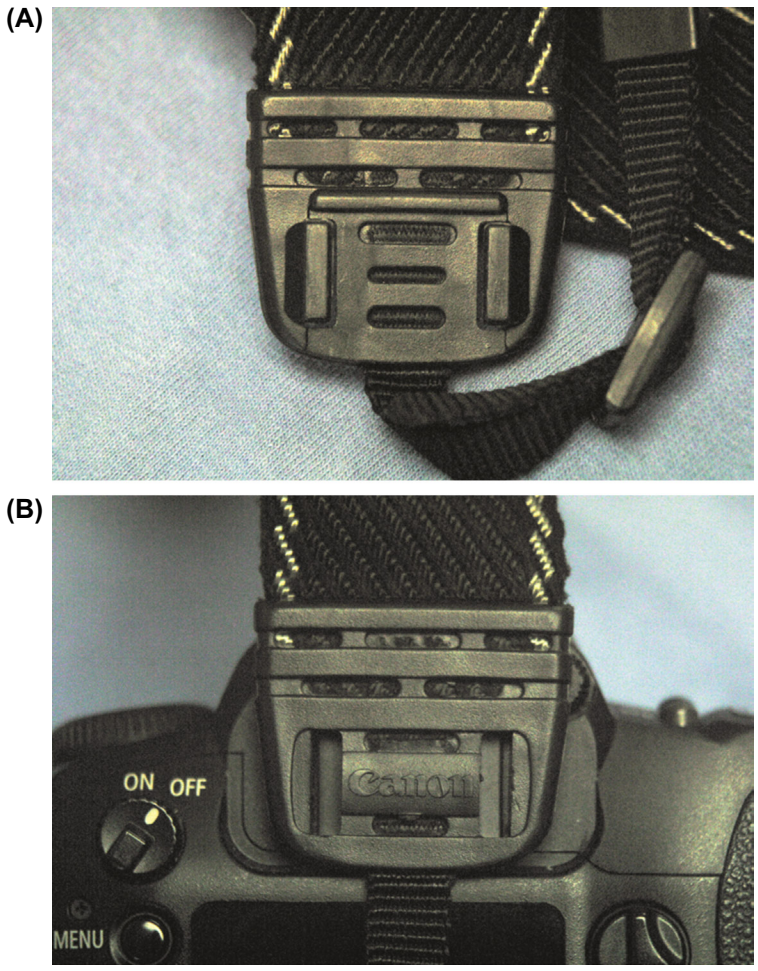


FIGURE 4.71
Eye cup cover on strap and over the viewfinder.

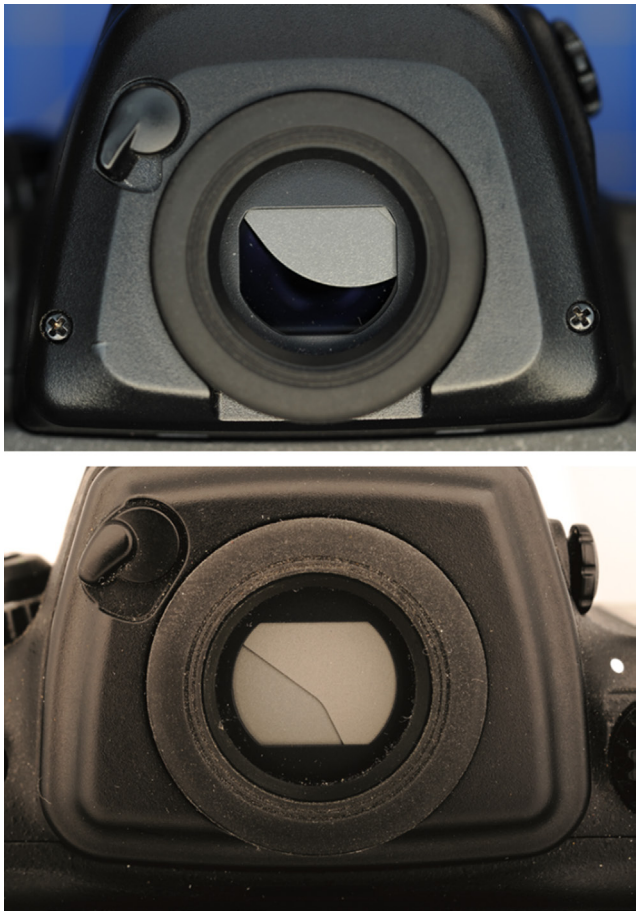


FIGURE 4.72
Newer Nikon cameras have built-in viewfinder covers.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

LEARNING OBJECTIVES, REVISITED

Determining the proper exposure for an image is an essential element of crime scene photography. This chapter explained the photographic variables related to exposure. Each exposure variable affects the ultimate exposure. One variable can be changed if another is also changed to maintain exposure equilibrium. The same overall exposure can be achieved with different exposure settings. This allows the photographer to capture a properly exposed image with different effects: different motion-stopping capability and different ranges of depth of field. First, however, the basic exposure elements must be understood.

Shutter speeds are not only exposure controls but also motion controls. The proper choice of shutter speeds not only eliminates the risk of blurred photographs resulting from the movement of the photographer at the instant the shutter is depressed but can also eliminate the blur that can be caused by the movement of subjects and objects within well-composed photographs. This chapter provided the information required to control motion and eliminate blur in photographs.

For any one exposure setting that the camera may indicate is a good exposure for a particular lighting condition, the photographer needs to be aware that other exposure choices will result in the same exposure setting. Then, from all of the available choices, the photographer must choose the particular combination that will produce the best possible photograph. This choice should be based on the conscious decision-making process of the photographer, not on the basis of an accidental camera setting.

To provide for well-exposed photographs, SLR cameras have to be able to measure the amount of light that is being reflected from the scene toward the camera and into the lens. That standard was explained here. Various light meters are in use in different cameras. These meters determine the adequacy of the light levels. Each was explained here.

The exposure meter is the "tool" used to determine a proper exposure. It indicates whether a "proper" exposure has been established or whether the scene is currently overexposed or underexposed. Different scenes reflect different amounts of light. "Normal" scenes will result in proper exposures. How can "non-normal" scenes be properly exposed? The answers were provided in this chapter.

When the scene of interest does not reflect "normal" amounts of light toward the camera, the reflective light meter in the camera body will not provide a "correct" exposure. Some well-known "tools" can be used to help the photographer determine a "proper" exposure in these cases. This chapter discussed four such "tools."

DISCUSSION QUESTIONS

1. What are the four variables that affect exposure? Why does changing one of them require an adjustment to one of the other exposure variables? What are the two main reasons for changing exposure variables while maintaining the same exposure?
2. How do different types of lighting affect the overall colors in your images?
3. What are two meanings of exposure latitude?
4. Shutter speeds affect motion. Which kinds of motion are affected?
5. To determine a "proper" exposure, you must use some standard. What is this standard? Explain "normal" and "non-normal" scenes. Presented with a "non-normal" scene, how can you determine the "proper" exposure?
6. There are various methods for determining "proper" exposures. What are the different exposure modes?
7. Explain the different methods to bracket a shot.
8. Explain the f/16 sunny day rule and its corollaries.
9. Explain the various filters commonly used by photographers and their effects on images.

EXERCISES

The following are composition and exposure exercises only. As such, issues of focus, depth of field, and flash techniques are not considered. You may use an SLR set to auto-focus. Composition and exposure are the only issues in these exercises.

Compare your images with those in this chapter and with other images on the Companion Website (http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646) of images, referring particularly to the following image folders: blacks, exposure, polarizer, shutter speed, sky, and whites. If using film, rather than a digital camera, make sure to tell the film processor not to make any exposure corrections when processing the film, because you have intentional overexposures and underexposures, and you do not want these "corrected" during processing.

1. Determine the proper exposure for one item that is totally sunlit and photograph it.
2. Determine the proper exposure for one item that is totally in the shade and photograph it.
3. Freeze a subject walking parallel to the camera's sensor 30′ from the camera.
4. Fill the frame with a sheet of white paper on which you have written your name. Photograph it after determining the "proper" exposure for it. Bracket +1 and −1.
5. Fill the frame with a black object. Photograph it after determining the "proper" exposure for it. Bracket +1 and −1.
6. Photograph a building façade that is in the shade.
7. Place an interesting object on your vehicle dashboard and photograph it through the windshield with a polarizer filter used to eliminate the reflections on the windshield.
8. From this same position, photograph the same object without the polarizer filter.
9. Place something in a shallow puddle and photograph it through the water with a polarizer filter used to eliminate the reflections.
10. From this same position, photograph the same object without the polarizer filter.

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CHAPTER 5

Focus, Depth of Field, and Lenses

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Acutance
Aberrations
APS-C Digital Sensors
Barrel Distortion
Circles of Confusion
Close-Up Filter Set
Depth of Field
Depth-of-Field Scale (DOF Scale)
Diffraction
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Focal Length
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Hyperfocal Focusing
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Image Stabilization
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Organization of Scientific Area Committees (OSACs)
Pincushion Distortion
Resolution
Scientific Working Group on Imaging Technology (SWGIT)
Scientific Working Group on Shoe Prints and Tire Tracks (SWGTREAD)
Scientific Working Group on Friction Ridge Analysis, Study and Technology (SGWFAST)
Telephoto Lenses
Vibration Reduction
Wide-Angle Lenses
Zone Focusing

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Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the terms "**Resolution**," "**Acutance**," and "sharpness";
2. Explain the concept of the "**Circles of Confusion**";
3. Explain how to hyperfocal focus on a scene by use of a **Depth-of-Field Scale**;
4. Explain how to hyperfocal focus on a scene without the use of a depth-of-field scale;
5. Explain how to zone focus on a scene by use of a depth-of-field scale;
6. Explain how to zone focus on a scene without the use of a depth-of-field scale;
7. Explain the three factors that affect **Depth of Field**;
8. Explain the techniques to maximize depth of field;
9. Explain the various designations of lenses: **Focal Length**, "fast" or "slow," and the widest aperture of the particular lens;
10. Explain what a reference to a "normal" lens means;
11. Explain the effects on a photograph produced by **Telephoto Lenses**;
12. Explain the effects on a photograph produced by **Wide-Angle Lenses**;
13. Explain the **Magnification Ratios** related to **Macro Lenses**;
14. Explain the meaning of the term "**Diffraction**" and how to minimize its effects on images;
15. Explain the difference between pincushion and **Barrel Distortion**.

FOCUS

An entire chapter devoted to focusing! How can that be? All you have to do is (1) look through the viewfinder, rotate the focus ring until your subject becomes clear, and take the shot; or (2) set the lens to autofocus, look through the viewfinder, depress the shutter button halfway to have the lens set the focus for the subject, and take the shot.

If the process were that simple, we could move on to the section Lenses. But it is not.

Although situations certainly exist when focusing with one of the preceding two methods is appropriate, on many more occasions different focusing techniques are better choices.

Snapshot shooters will find it unbelievable, but many times it is best to (1) focus the camera without looking through the viewfinder or (2) look through the viewfinder and focus at a location where no evidence exists.

Experienced crime scene photographers understand the concept of focusing on particular areas rather than just individual objects, but others may be confused.

The best way to introduce these new ideas is to point out the obvious. When arriving at a major crime scene or major accident scene, law enforcement photographers photograph not only individual items of evidence within the scene but also the scene itself. The scene itself is an area within which the individual items of evidence are located. Crime scene photographers photograph both crime scenes and accident scenes (areas) and individual objects.

The photographs taken by most people not in law enforcement are very different. Most photographs captured by the general public are of individual items. We photograph our family members, our boyfriends or girlfriends, our pets, a birthday cake, and the turkey on Thanksgiving. Even when the general public photographs more than one individual or object, it frequently is really just "one" thing. Two or three buddies shoulder-to-shoulder are a pair or a trio—one pair or one trio; one grouping. Four bridesmaids lined up for a photograph are more often than not in a tight group or a single line—one group or one line. When we photograph a line of trophies on the mantle, that really is just one grouping of several items.

But crime scene photographers must spend considerable effort capturing images of medium and large crime scenes, as well as individual items within the crime scenes. These crime scenes differ from the subject matter of most photographs. Foreground detail and background detail are present, and all the items of evidence within this area are present.

A new Rule of Thumb is appropriate here.

RULE OF THUMB 5.1

The entire scene, and all the evidence within the crime scene, should be in focus. If you know a part of the scene will be out of focus if the photograph is captured as composed, you should attempt to recompose the scene so the out-of-focus area is no longer in the field of view.

Ensuring an entire area, from foreground to background, is in focus requires very different focusing skills. It is relatively easy to focus on just one item. How do you, however, focus on an area that is 10′, 15′, or 40′ deep? That is partially what this chapter is about.

Why is ensuring that the entire crime scene is in focus important? Ultimately, crime scene photographers take photographs at crime and accident scenes so that, if needed, they will be admissible in court as evidence. A chapter on the admissibility of photographs in court as evidence is provided later in this text. For now, consider just three possible objections a defense attorney might be able to come up with when crime scene photographers try to offer the court a partially out-of-focus image as evidence. The following three "objections" have been created by the author to emphasize the importance of ensuring as much of your image as possible is in focus. The list of court citations in chapter "Legal Issues Related to Photographs and Digital Images," related to the admissibility of images, both film and digital, do not contain one case in which an image was held to be inadmissible **only** because it was out of focus. Nevertheless, this author is using these fictitious objections as a means to highlight the importance of focusing to maximize your depth of field (DOF), which is one of this author's Cardinal Rules.

> "Your Honor, I object to this image. It is clearly out of focus" (in the foreground, or the background, or somewhere). "When this photographer was at the crime scene, as he or she looked around the scene, it was all seen in focus. Why are we not afforded the same opportunity to see the scene completely in focus? A partially out-of-focus photograph does not meet the standard of being a fair and accurate representation of the scene. How can it be fair or accurate if parts of the image are out of focus? Exclude this image!"
>
> "Your Honor, I object to this image. It is clearly out of focus" (in the foreground, or the background, or somewhere). "I submit that the crime scene photographer intentionally blurred part of this scene to hide certain items of evidence from us. He made certain that the evidence he thought was important was in focus. How can we ascertain whether other evidence, possibly exculpatory to my client, was intentionally blurred because it did not coincide with his or her premature conclusion that only my client was guilty of this crime? It is common knowledge that photographers intentionally blur parts of photographs to force the viewer to look at just one part of the image area, while hiding other areas of the image area in blur. This photographic trick highlights part of the image and hides other parts. Do not be tricked by this photographer. Exclude this image!"
>
> "Your Honor, I object to this image. It is clearly out of focus" (in the foreground, or the background, or somewhere). "Either the photographer is trying to trick us by intentionally hiding aspects of the crime scene (as in the objection immediately preceding), or the photographer is incompetent, in which case this image should not be admissible as evidence, because you should not allow inferior representations of the crime scene into this trial. If the (insert your own agency name here) thought an aspect of this crime scene was important enough to photograph and to offer it as evidence in this trial, they would have sent an experienced and competent photographer to do the job. Judge, do not accept mediocre work. A blurry photograph is neither a fair nor an accurate depiction of the crime scene. Exclude this photograph!"

Again, these are all fictitious objections. However, they do set the groundwork for the remainder of this chapter, which emphasizes focusing and DOF.

Focusing on individual items of evidence and entire crime scene areas are two different skill sets. Both are critical.

Resolution, Acutance, and Sharpness

Before focusing techniques are explained, you must first understand what it is to be "in focus." To do this, it is necessary to differentiate three terms: "resolution," "acutance," and "sharpness." Images are often said to be "in focus" or "sharp" or "clear" as if these words all meant the same. Let us be a bit more precise.

Resolution

Camera resolution is the ability of the camera system, which includes the lens optics, camera sensor, and image-processing software, to distinguish, or "resolve" groups of alternating line pairs as the lines become increasingly thinner and they become increasingly closer together.

The classic line pair consists of a black line and a white line. As multiple line pairs become thinner and closer together, at some point the distinction between the black lines and the white lines will become less distinct; the result becomes a blending into gray.

A variety of resolution charts are available to measure relative resolution. Fig. 5.1 shows an example. In Fig. 5.1A, a section of a resolution chart is encircled with a red oval, which is enlarged in Fig. 5.1B. The blending of the white and

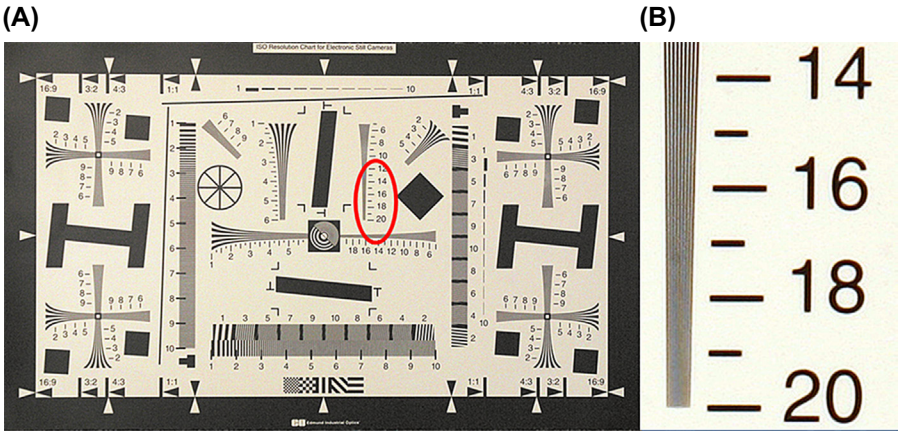


FIGURE 5.1
(A) Resolution chart. (B) Close-up of oval on 5.01.

black lines into gray is not an example of blurring from motion; it is an example of the inability to properly "resolve" the individual white and black lines.

You can compare the relative resolution capacity of different lenses when used on the same camera body or the same lenses when used on different camera bodies. You can also compare one manufacturer's camera body with its highest grade of lens at one particular focal length with another manufacturer's camera body and lens.

At one time, the particular interest in most photography magazines found on grocery store and drugstore shelves was the comparison of resolution between film cameras and digital cameras. Digital camera websites were also frequently discussing this question. Law enforcement agencies had also constantly asked, "Do digital cameras have the same resolution as film cameras yet?" The answer to those questions has been determined: digital cameras with megapixel counts at or above the 13.5-MP level certainly can match the resolution once enjoyed exclusively by only film cameras.

RESOLUTION STANDARDS/GUIDELINES

Are official standards offered for the minimal digital resolution necessary to do a particular job? Yes. One standard is not used for crime scene photography, however. It relates only to the electronic transmission of 10-print facsimiles.

When Automated Fingerprint Identification System (AFIS) computer networks were developed, it was necessary to develop a standard by which copies/facsimiles (faxes) of 10-print cards could be sent from one jurisdiction to another. One jurisdiction may have a freshly developed a latent fingerprint from a crime scene that was tentatively "matched" to a known print in the files in another jurisdiction. As a point of clarification, AFIS systems do not make "matches." They come up with a list of "candidates" that have similarities to a latent print of interest. Only latent print examiners can make identifications. Unfortunately, in the popular media, such a "candidate" is frequently misnamed an "identification." So that a latent print expert could confirm this "match," the 10-print card had to be faxed to the jurisdiction holding the crime scene print. A minimum standard for the quality and resolution for the fax machine had to be developed. The National Institute of Standards and Technology (NIST) ultimately decided on 1000 pixels per inch (ppi) at 1:1 as the minimum resolution.

A **1:1 Magnification Ratio** occurs when an item of evidence is life size on a sensor. As stated previously, the full-sized digital sensor is 24 × 36 mm in size, the same as film had been. A single-digit fingerprint fits nicely within the bounds of a 24 × 36 mm area, also understood to be 1″ × 1.5″ (Fig. 5.2).

As long as the fax could produce 1000 ppi resolution, it could adequately transfer copies of 10-print cards through the wires. It is probably improper, however, to consider this fax resolution a standard to apply to crime scene photography. Therefore, (1″) (1000) × (1.5″) (1000) would be the necessary resolution for a digital camera to adequately capture a single-digit fingerprint; 1000 × 1500 = 1,500,000, or 1.5 MP.

Today, when single lens reflex (SLR) digital cameras are readily available in 16 MP up to 24 MP, this seems like an easy standard to be bound by. It is a deceiving standard, however. What if the evidence necessary to be captured by a digital camera is larger than (1″) × (1.5″)? If this same standard was used, what would this mean if an item of evidence fits within a (2″) × (3″) area? Because this area is twice the area of (1″) × (1.5″), does this not also mean the digital resolution is simply doubled to require a 3-MP camera? No.

Consider this: 2″ (1000) × 3″ (1000) = 2000 × 3000 = 6,000,000, or 6 MP. Doubling the size of the evidence requires **quadrupling** the resolution of the digital sensor. That means photographing two adjacent fingerprints would require

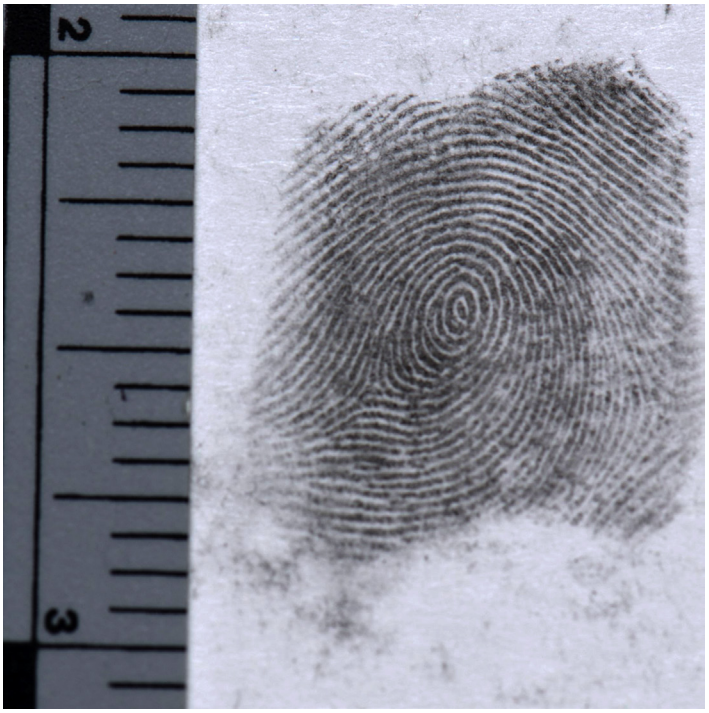


FIGURE 5.2
1:1 fingerprint.

a 6-MP digital camera. It would also mean that if the evidence filled a (3″) × (4.5″) area, (3″) (1000) × (4.5″) (1000) = 3000 × 4500 = 13,500,000, or a 13.5-MP camera would be needed. If this standard were the required standard for **all** evidence, not just faxes, some evidence larger than (3″) × (4.5″) would not be able to meet that standard. The NIST standard of 1000 ppi for known fingerprints to be sent by fax, however, is not applied to any other type of evidence.

It must be mentioned that as this third edition is being prepared for publication, in the summer of 2016, all the previous Scientific Working Groups have been reimaged into the US Department of Justice (DOJ) and the NIST **Organization of Scientific Area Committees (OSACs)**. A specific SAC covers disciplines related to Physics/Patterns, including subcommittees on Friction Ridges and Footwear and Tire Treads. New guidelines from these two committees have not yet emerged. It is expected that they will be considering issues of the minimum digital camera resolution for various jobs, and printer resolutions necessary to enable the high-quality digital images are replicated in printed photos.

It is interesting to note that just 5 years ago, we were still struggling with determining just when a digital camera had the resolution that film once had. Now, just the opposite has become true. Nikon and Canon cameras can now be found with 36 and 51 MP, respectively.

In a recent photo of a ninhydrin-treated latent print, a 36.3-MP Nikon D810 was used to fill the frame with the image, and the image was captured as RAW + JPG. When the RAW image was processed, it showed the friction ridges just fine but also captured the ninhydrin-stained paper pulp at the same time. Now photographers may have the same problem as DNA analysts are having with "touch" DNA. The DNA technology is becoming so advanced that mixtures are also being recovered. As the resolution of our digital cameras become higher and higher, this may become a constant interference we will have to learn to deal with. How was this background interference dealt with? When the JPG image file was opened, its compression of some of the detail of the image eliminated any view of the stained paper pulp. Who would have imagined we have come to the place where having too much resolution becomes a problem, and the solution is to use a JPG?

Acutance

Acutance refers to the camera's ability to render a sharp edge of the subject as a sharp edge in the photograph.

This is obviously part of what we think of when we speak of sharp focus and good resolution. Acutance means a clear and precise distinction exists between the edge of one object and the beginning of the adjacent substrate it is on. Referring back to resolution and the line pairs it deals with, if a white line were adjacent to a black line, the edge between them would be crisp and well defined, with no overlap between the two.

The concept of edge sharpness will be revisited in the section Diffraction. Images of sharp-edged items will be shown that do not replicate the sharp edges of the object. The causes and possible solutions to this problem will be discussed later in this chapter.

Sharpness or Being in Focus

When you think of an image being in focus, you usually think of light coming into the camera through the lens and converging at the sensor at a precise point. As light makes its way through the lens, it becomes a smaller and smaller circle, which looks like the converging ellipses in Fig. 5.3. When the light comes together as a point on the sensor, that is called "being in focus."

Fig. 5.4 shows the light coming together at a point in front of the sensor and then continuing on until it strikes the sensor as a small circle. In this case, the image will technically be "out of focus."

Fig. 5.5 shows the light unfocused until some distance after the sensor. Of course, the light cannot travel through the sensor to focus behind it. But, when it strikes the sensor, it is also a small circle. In this case, again, the image will technically be "out of focus."

These simplistic graphics are presented to introduce the concept of the circles of confusion. Simply stated, as long as the light, reflected from a single point in space, enters the lens and remains a circle, rather than coming together at the sensor at a specific point, the image can be considered "confused" and "out of focus." It does not matter whether the light would have become a point in front of or after the sensor. If a circle of light is formed on the sensor, the result is an "out-of-focus" image.

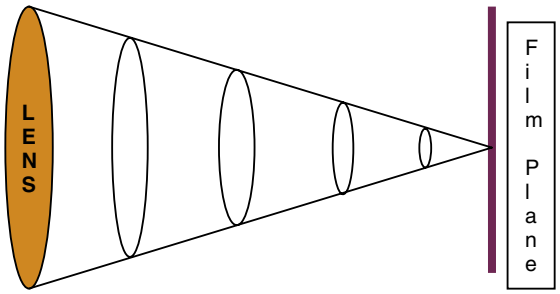


FIGURE 5.3
Light rays converging at film plane.

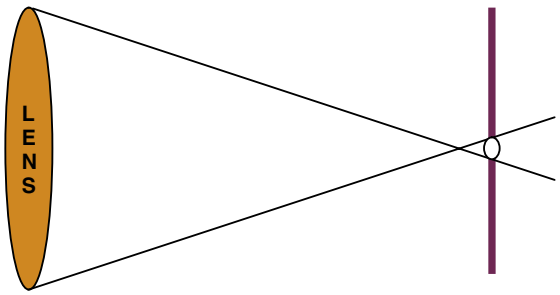


FIGURE 5.4
Light rays converging before the film plane.

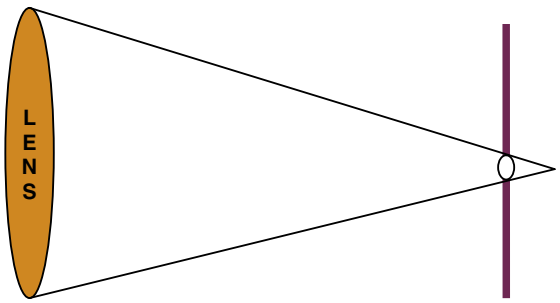


FIGURE 5.5
Light rays converging after the film plane.

Of course, the concept of **DOF** is temporarily being ignored, which is the extended area in front of and behind the plane of precise focus that still appears to the eye to be in focus.

Consider this explanation of the circles of confusion to be the purely mechanical definition of a point in critical focus. We will get to DOF soon.

Manual Focusing

When the word "focusing" is mentioned, most people think of the manual focusing technique. To manually focus a camera, you simply rotate the focus ring while looking through the viewfinder until the object/person of interest comes into focus, which is the way most people focus a camera. However, whenever more than one object/person, at different distances from the camera, is of interest, then you need a different strategy to ensure all the items/people are in focus at the same time.

Focusing on just one item at a time is the perfect situation for using the manual focusing technique, which presumes, of course, that the item is composed with the film plane parallel to the item of evidence. That Cardinal Rule certainly applies here. If, and only if, the entire item of evidence is composed with the film plane parallel to it, manual focusing will be successful. If the item of evidence is (mistakenly) composed from a diagonal point of view, the manual focusing technique may not be successful.

Fig. 5.6A shows a photo of a semiautomatic pistol taken with the film plane parallel to the top surface of the weapon. Because the entire surface of the pistol is the same distance from the camera, it is completely in focus. You expect an



FIGURE 5.6
(A) Gun, film plane parallel. (B) Gun, oblique camera viewpoint.

entire item to be in focus when a photograph is taken. But, sometimes, expectations are not met. Fig. 5.6B shows the same pistol. In this shot, however, the photographer assumed a diagonal point of view to the pistol. The focus point was the near end of the muzzle. The muzzle is closer to the photographer than the pistol's grip. It is evident that as you look further along the pistol, from front to rear, the weapon begins to become "softer." The entire pistol is not in focus. The carpeting just beyond the grip is noticeably "softer" also.

The series of images in Fig. 5.7 show another variation of this. This knife is a bit smaller than the pistol in Fig. 5.6. To fill the frame with the knife, one would have to get closer to it. As we will learn later in this chapter, as one gets closer to an item, the DOF gets shorter. Now, we can see in Fig. 5.7B that when one focuses of the name of the blade the handle can become very "soft," and when focuses on the back of the handle (Fig. 5.7B), the tip of the blade can go "soft."

Manual focusing on single items of evidence is best done with the film plane parallel to the top surface of the evidence.

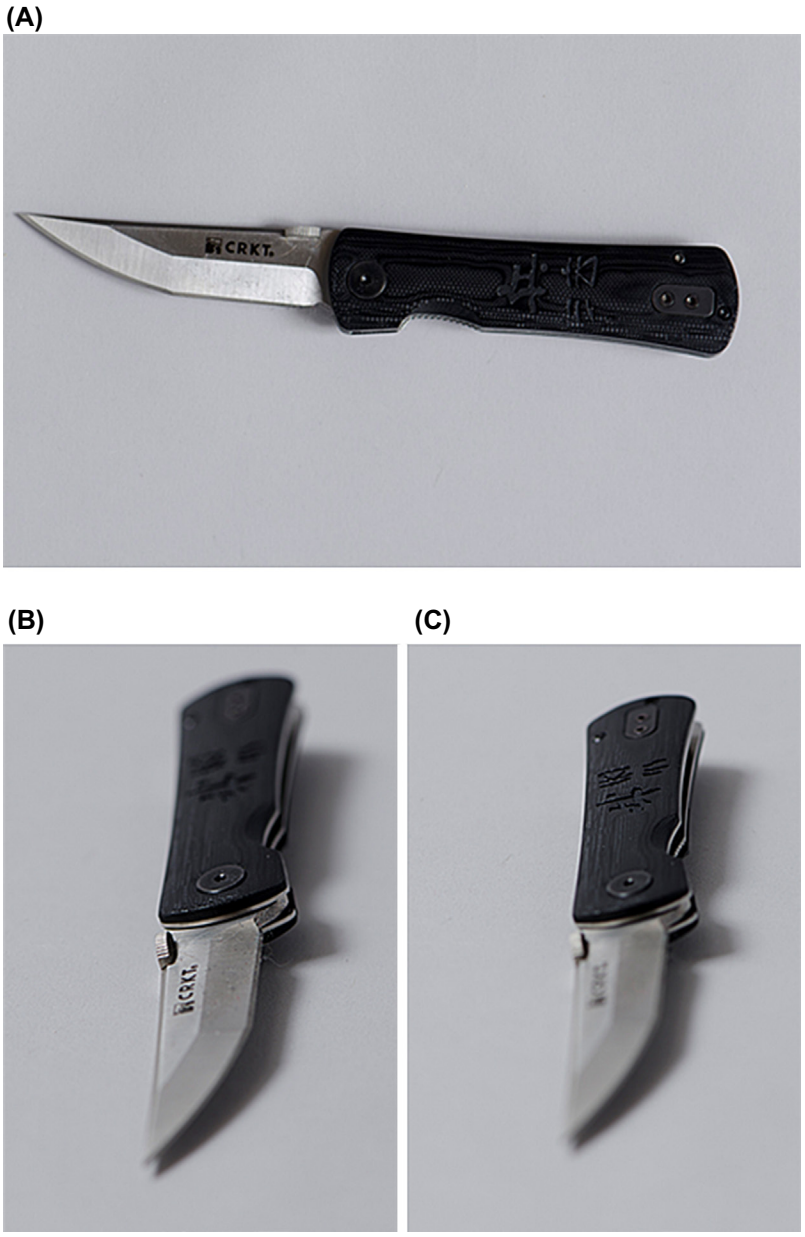


FIGURE 5.7
(A) Knife, film plane parallel. (B) Knife, name in focus. (C) Knife, handle in focus.

Automatic Focusing

Many newer cameras have autofocusing capabilities. Basically, when the shutter button is depressed halfway, these cameras usually focus on the object in the center of the viewfinder, although the location of the autofocusing point can be changed in the viewfinder. Different camera manufacturers have different methods of indicating just what this autofocus point is. Frequently, it is designated by a small rectangle or circle in the center of the viewfinder. Consult your camera manual for these variations.

Caution, however, should be used when using autofocus. The improper use of autofocus is often the explanation for out-of-focus photographs. How can this be?

An example may help. At a homicide by throat slashing, a crime scene photographer tried to photograph a gaping wound to the victim's neck, and this crime scene photographer was in the habit of using the autofocus capability of the camera. All of the photographs came back with the chin of the victim in focus and the wound out of focus. What happened? The autofocus locked on the chin, without the crime scene photographer noticing it. The proper use of the autofocus capability of the camera would have resulted in a better image. But, in this case, the crime scene photographer relied on the automation of the camera to do his job for him. The camera did, in fact, attain focus on part of the scene, just not on what the photographer was really interested in.

Many teachers of basic photography techniques require their students to use only manual camera settings. It is best for students to learn to be totally responsible for the net product of their efforts. Relinquishing responsibility for any of the camera's functions to a camera's automatic functions is not the proper way to learn photography. It is better to have well-trained crime scene photographers than to have "intelligent" cameras making decisions which the photographer should be making. Teachers often tell students that we can either teach them photographic theories and principles, or the students can just leave their "smart" cameras in class and then go home. It is much better for photographers to learn how to use every facet of the camera kit than for them to rely on the camera to make certain decisions for them.

Moral: The photographer is responsible for the final quality of the image. Blaming an automatic feature of the camera equipment for a marginal or unacceptable photograph is a poor excuse. If you choose to use any feature of a camera, you must use it correctly and be responsible for the results.

The autofocusing capability of a camera can be used effectively; it is just important to be aware of what the camera has locked onto before the shutter is fully depressed to capture the image.

When to Use Autofocus

When many purchasers are willing to spend additional money on an autofocus camera, how can anyone justify a recommendation not to use it? It is certainly a valued feature of many cameras. However, many general-purpose camera purchasers also demand a camera with autoexposure, or program exposure mode. It is said that many purchasers of cameras want the camera to automatically make all the "complicated" decisions for them so that they can concentrate on more "creative" aspects of photography. Crime scene photographers usually fall into a different class. The images the crime scene photographers capture can help put someone in prison. The images the crime scene photographers capture can help convict a defendant ultimately sentenced to death. These images usually are more purposeful than those captured by the general public.

When would the autofocus mode be appropriate for crime scene photography? Certainly, when only one main subject is in the field of view, autofocus may speed things up a bit without having the photographer relinquish any responsibility.

In a surveillance situation, when it can be anticipated that the subject will be moving toward the camera or away from the camera, predictive autofocus may be the only way to capture the image. Predictive autofocus enables the camera to track a moving subject at different times at different distances from the camera. Presuming that the subject is moving at a more or less constant rate, the camera's computer can determine the anticipated distance change in a given amount of time and automatically focus the camera for the position where the subject will be in the next instant. It would be impossible to hold the camera and continually make fine refinements to the focusing in situations like this, which is one time the technology must be used to capture the desired image.

An experienced photographer, knowledgeable about when auto-focus is likely to be unsuccessful in attaining accurate focus, can also use autofocus. With more awareness on the part of the photographer imaging, the slit neck in the homicide situation mentioned previously, autofocus could have been successful. Achieving the right result just takes a photographer aware of what the camera is doing.

Difficult-to-Focus Subjects for Autofocus

When is autofocus likely to fail? Some autofocus cameras require subject matter that has prominent vertical elements, and some require prominent horizontal elements. Check your camera's manual. In either case, when the subject matter lacks distinct detail for the camera's focusing system to lock onto, the autofocus capability of a camera may fail, which can usually be noticed by the focusing system continually searching for something to grab onto, moving throughout its focusing continuum and never locking at any one distance. Frequently encountered examples of this type of subject matter are a uniformly blue sky or an interior wall with a single color on it.

If the camera's focusing system fails to lock onto something, usually two options exist: attempt to find a substitute object to focus on at approximately the same distance from the camera. Focus on it, by depressing the shutter button down halfway, keep the shutter button partially depressed, swing the camera around to the primary subject, and depress the shutter button the rest of the way. Or, switch to manual focus.

Autofocus may also fail in dim, low-light conditions. Under these conditions, some cameras may have the capability of emitting an infrared pattern that projects onto the subject, and the camera then focuses on this infrared pattern. If your camera does not have this capability, switching to manual focus may be your only alternative.

Conversely, bright lights or strongly backlit scenes may "confuse" a camera's autofocus system. If a surface is reflecting specular elements, the autofocus system may fail.

When nearby and distant elements are near the center of the viewfinder, the autofocus system may not be able to decide which is the intended target and give up trying. One example is a caged animal in a zoo. If the bars or wiring are too close to the animal in the field of view, the camera may not be able to decide if the relatively close cage or the distant animal is the prime subject matter. In these situations, you may have to switch to manual focus.

Finally, if two distinct types of subject matter are near each other, the autofocus system may successfully focus on one of them when it was really the other object you were concerned with. Remember the chin and slit neck situation mentioned earlier. Double-check that the autofocus system is focusing on what is important to you. Or, rely on manual focus and feel assured you will infrequently focus on an aspect of the scene unimportant to you.

Focusing With a Zoom Lens

Many crime scene photographers have a zoom lens as their primary lens. Frequently encountered are zoom lenses like 35–80 mm or 28–105 mm. Many years ago, a distinct advantage existed to the use of a prime lens with only one focal length. Such lenses were clearly sharper and had fewer lens **Aberrations**.

Lens design and construction has significantly improved to the point where there is no longer a negative stigma attached to using a zoom lens. Indeed, some excellent zoom lenses are on the market. However, there are still some unwanted effects of using either the wide angle or telephoto options on these zoom lenses. This is very important to remember when doing examination quality photographs: especially when doing photos of fingerprints, shoe prints and tire tracks. When these types of photos are being taken, try to stay with the "normal" focal length to the extent you can. Wide-angle lenses are known to suffer from "barrel" distortion. See Fig. 5.8. Barrel distortion is characterized by straight lines near the periphery of an image bending outward. Now consider taking a close-up of a bloody shoe print pattern with a zoom lens. If you select a wide-angle focal length to capture this close-up, you may be changing the shape of the shoe print to the extent it cannot be compared to a suspect's shoe.

Consider taking that photo with the zoom lens set to its telephoto focal lengths. Telephoto lenses are known to distort images with a "pincushion" look which has straight lines at the edges of an image seeming pinched in a bit; see Fig. 5.9. True, using the tele setting of the lens would enable you to stand at your full height to focus through the viewfinder, rather than bending over, but is this benefit worth the price?

If a zoom lens is regularly your lens of choice, or if it is what your agency has provided you for the job, how can you use it to maximize your focusing task? As mentioned previously, many zoom lenses include a wide-angle range and a telephoto range. One of the known benefits of telephoto lenses is their magnification capability. Would you rather focus on an object when it is small and difficult to see, or when it is larger and more clearly defined? Obviously, the latter. If a zoom lens is the tool you are currently using, use it efficiently. To focus on any subject, zoom the lens to its telephoto setting to use its magnification capability. Focus. Reset the lens to the focal length you want to use, and be comforted in the knowledge that once you have focused the lens at any focal length setting, selecting a different focal length does not defocus the lens. Know the tool, and use it appropriately.

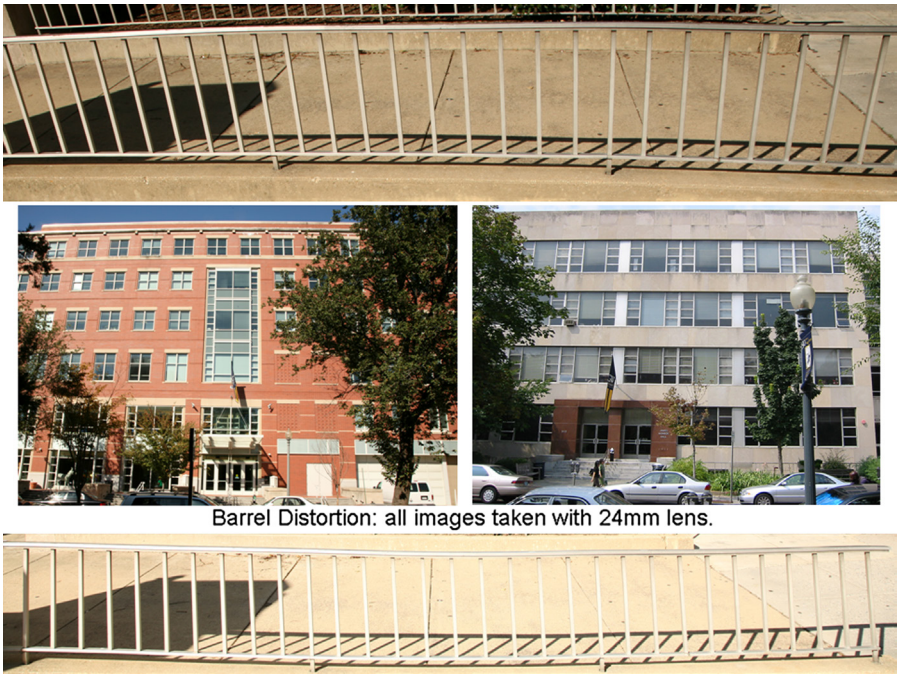


FIGURE 5.8
Barrel distortion.



FIGURE 5.9
Pincushion Distortion.

Prefocus

This author once worked with a crime scene technician who would enter a crime scene, raise the camera to his eye, and then move forward and backward until the subject became sharp. Definitely, not the normal way of focusing. However, under one circumstance, this is exactly the best way to focus a camera. Have the camera prefocused, and then move the camera toward and away from the subject until the subject matter becomes sharp.

What is this circumstance? It is when you intend to take a series of bracketed images of a fingerprint. In this circumstance, you will set the camera so it captures a 1:1 magnification of the fingerprint, which is when the single fingerprint fills the frame in the field of view, also ensuring the fingerprint is life-sized on the sensor. Consider the images in Fig. 5.10. A single-digit fingerprint nicely fills the frame when magnified to 1:1.

Why prefocus? For two reasons.

One alternative is to put your camera on a tripod, set the tripod down an arbitrary distance from the fingerprint, and then begin focusing by turning the focus ring. You may focus and focus and focus, and then eventually realize the camera is **too close** to the fingerprint to ever achieve proper focus. Every lens has a close focusing distance. Closer than this distance, the lens cannot focus. Placing the tripod down at this distance is a waste of time and makes you look as though you do not understand your own equipment. Not a good way to earn the respect of your peers.

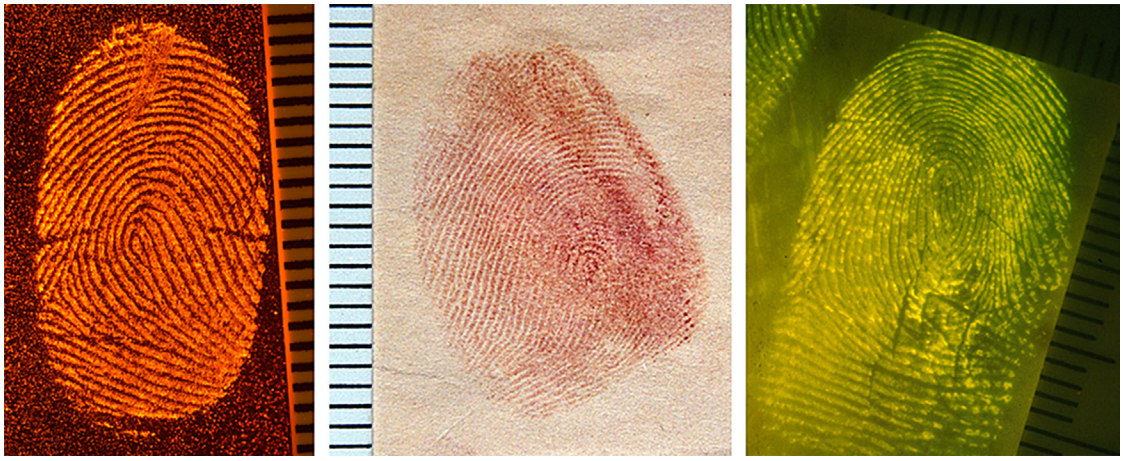


FIGURE 5.10
1:1 fingerprints.

If you place the tripod **too far** from the fingerprint, the camera will eventually be able to focus. However, if you are further than need be, when you do achieve focus, the fingerprint will be smaller than optimal. Remember the Cardinal Rule, Fill the Frame? In this situation, it counts. If the camera is further from the fingerprint than necessary, the fingerprint is smaller on the negative. If the fingerprint is not as large as possible, you are using too many digital pixels capturing nonfingerprint detail. Why waste your sensor's ability to capture detail of irrelevant space?

Prefocus the camera to its closest focus distance. One end of the focusing continuum is infinity; the other end is the lens' closest focusing distance. This can be done without looking through the viewfinder. Just look down on the lens and adjust the focusing ring until it stops at the short end of its distance scale. Having prefocused the camera, move the camera mounted on a tripod toward the fingerprint until the fingerprint comes into focus while you look through the viewfinder. In this situation, all other focusing techniques are second best.

Hyperfocal Focusing

Many times crime scene photographers must capture entire crime scenes and areas in focus rather than individual items of evidence. As mentioned earlier, focusing on areas requires a different skill set. In the normal sequence of crime scene photography, photographers frequently must capture images of large outdoor crime scenes. If the crime occurred indoors, photographers frequently begin by photographing the exterior of the building in which the crime occurred and the surrounding areas by which any suspects could have gained ingress and egress. These are large areas. What is the proper technique to maximize the DOF with large exterior crime scene photographs?

It might be good to revisit the definition for DOF. DOF is the variable area, from foreground to background, of what appears to be in focus to the eye. It is a variable area because photographers can select camera variables that restrict the DOF to just one plane or just one distance from them. Or, photographers can select camera variables that maximize the DOF, ensuring large areas are in focus when the photographic print is eventually made.

This situation is made more complicated because the camera usually shows only one plane, or one distance from the camera, to be in focus at a time. When looking through the viewfinder, you usually see only one area of the scene in focus at a time. Why is that? Did you know that until you depress the shutter button the whole way, the lens is automatically set to its widest aperture? This is so that you can see the scene with enough light to be able to focus. Using any aperture, but the widest one, makes it more difficult to see and focus on the scene. Well-trained crime scene photographers, however, will be confident that when the image is printed, more than what they saw through the viewfinder will be in focus.

The three images of Fig. 5.11–5.13 show this ability to manipulate the area in focus to suit the photographer's needs. Fig. 5.11 shows a restricted DOF, with only the front of the numbered evidence markers in focus. Fig. 5.12 transfers this narrow area that is in focus to the rear numbers. Finally, by choosing the correct camera variables, the photographer can maximize the DOF range and have all the numbers in focus at the same time, as in Fig. 5.13.



FIGURE 5.11
Wide aperture, focused on #1.



FIGURE 5.12
Wide aperture, focused on #15.



FIGURE 5.13
Small aperture, all in focus.

An astute student asked why, when the first evidence marker was focused on, there appears to be more out of focus evidence markers than when focused on the last one, even when the same f/stop was used for both. Think about that a bit, and it will eventually be answered.

Here, then, is a new Rule of Thumb.

RULE OF THUMB 5.2

If you are composing on an area as your "primary subject," that entire area should be in focus.

Why include an area in your composition if you know it will be out of focus? Another way of saying the same thing is this: if you know an area will be out of focus, exclude it from your composition. Do not give anyone the opportunity to criticize your photographs because areas are out of focus.

This may be the first time this author's pedagogical style has been so blatant. Crime scene photographers capture very important images. The consequences to the defendant are enormous. The responsibility of photographers is, therefore, just as weighty. The chapter "Composition and Cardinal Rules" mentioned the photographer's full field-of-view responsibility. Do not take this lightly. Purposefully include in your photographs only the details you wish in them; exclude from your images as much as is irrelevant as possible. Once you have decided what will appear in your field of view, you now have the obligation to ensure it is well exposed. But achieving a proper exposure is not sufficient. It is just as important to ensure it will be in focus. Certainly, you will not be considered much of a photographer if your well-exposed detail is out of focus. So, too, having in-focus detail improperly exposed is just as problematic. Photographers have the responsibility to compose, expose, and focus properly on their subject matter.

Hyperfocal Focusing is the technique to maximize the DOF when infinity is composed in the background. Infinity (∞) is normally considered an unimaginable large number, a large distance, or a large quantity. On a camera's focusing ring, however, infinity is more mundane.

In the two images of Fig. 5.14, the top two rows of numbers are distance indicators, one in feet (top row/green) and one in meters (second row/white). Notice that infinity (∞) is the next figure after the 10-m mark. As the distance indications move from left to right, they seem to be getting progressively closer together. The space between the 2-m mark and the 3-m mark is larger than between 3 and 5 m. The space between 5 and 10 m is smaller yet, which suggests that if an actual number had been printed on the distance scale in place of the infinity symbol, it would be perhaps 20–30 m or so. What this means, for all practical purposes, is that as far as the camera is concerned, infinity is the equivalent of about 60–90 ft and beyond.

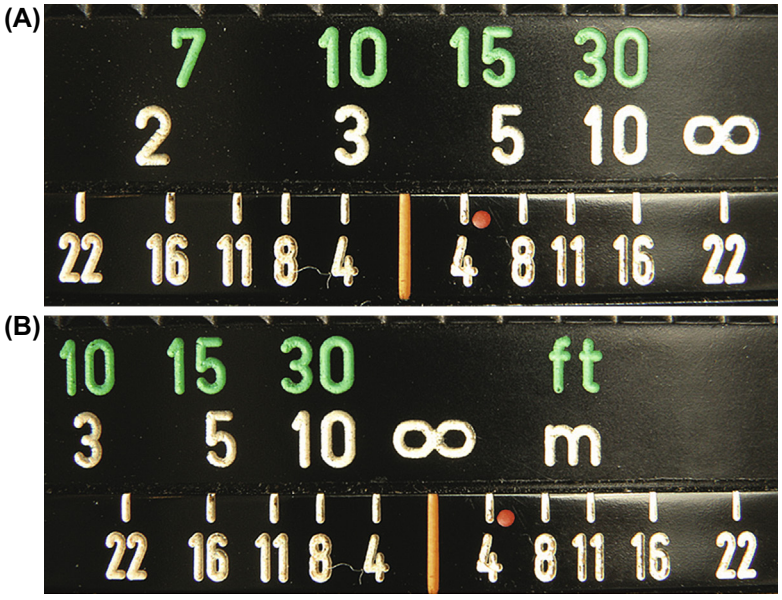


FIGURE 5.14
(A) Depth-of-field scale: pairs of numbers opposite the orange line. (B) Focused on infinity.

Thinking like a camera, then, you can place photographs into three rough categories:

1. Large scenes, with infinity in the background.
2. Medium distance scenes, where infinity is not in the background.
3. Small areas and close-up images of individual items of evidence.

Hyperfocal focusing is the focusing technique for the first category, when maximizing DOF is the primary concern. If you accept Rule of Thumb 5.2 and wish to ensure that infinity must be in focus if it is in the field of view, you may be tempted to actually focus on infinity.

Look at Fig. 5.14B above, which shows a camera focused on infinity. The focusing line is aligned with the infinity symbol, which is the most efficient way to ensure infinity will be in focus, right? Wrong.

Fig. 5.14 also shows a third row of numbers beneath the distance rows. These are pairs of numbers on either side of the focusing point called the depth-of-field scale (DOF scale).

Some lens manufacturers include this very handy scale on their lenses. Unfortunately, a trend to omit this scale on many newer lenses seems to exist. Do not fear. This text will provide suggestions for hyperfocal focusing whether or not your particular lens actually has a DOF scale.

What is the DOF scale? The DOF scale is a tool to enable photographers to determine the DOF, the area that will appear to be in focus when the image is processed. Remember, when you are looking through the viewfinder, only one distance from the camera appears to be in focus at any time. You must somehow know that more than just one distance will be in focus when the image is printed, depending on the camera controls selected.

As previously indicated, only one point exists where the light coming in through the lens will come together to form an exact point on the sensor. If the light coming in through the viewfinder formed a circle when it reached the sensor, as indicated previously, the result would be an out-of-focus image. Now is the proper time to refine that simplistic explanation of focusing. To do this, we must understand the concept of the circles of confusion in more depth.

The notion that being in focus only occurs when light meets at a single point on the sensor is a very mechanical explanation. In fact, the eye is a very remarkable sensor. It can actually detect some of the light striking the sensor as small circles as being in focus, which means that instead of a single distance from the camera appearing to the viewer as being in focus, an area before the point of exact focus appears to the viewer to be in focus, and an area behind the point of exact focus also appears to the viewer to be in focus. Some of the light striking the sensor as small circles is perceived to the viewer as being in focus, just as the light striking the sensor at a single point.

Research has shown that circles striking the sensor as large as 0.025″ to 0.033″ in diameter will appear to the eye to be in focus. You may not be able to imagine circles with that diameter range, so it is difficult to grasp this concept with just this information. Graphics help immensely, and perhaps they will make the concept easier for us to understand.

Although the circumstances in Fig. 5.15 cannot exist in reality, because light cannot travel past the sensor, this graphic does make it somewhat easier to understand DOF. Consider the small shaded circles to have a diameter of between

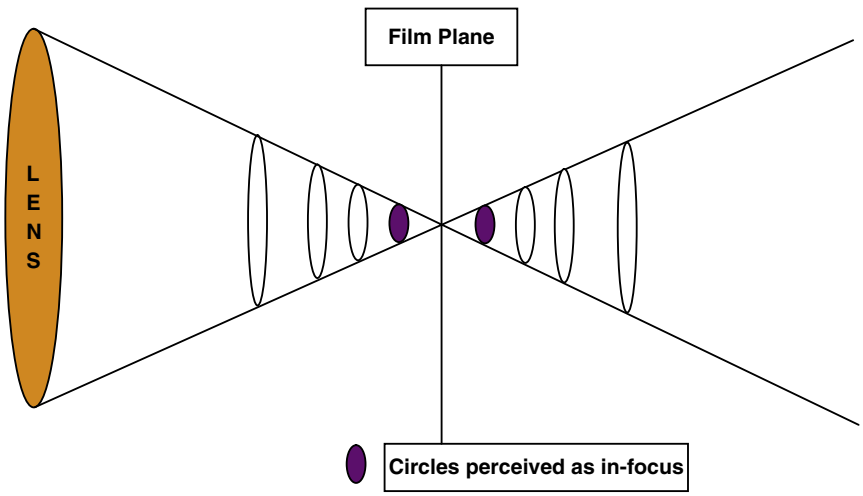


FIGURE 5.15
In-focus circles of confusion; large aperture.

0.025″ to 0.033″, which is the resolution limit of the eye. Light coming together at the sensor that is not in perfect mechanical focus, forming circles of this size, or smaller, will still appear to the eye as being in focus. Naturally, the point at which light actually intersects the sensor at a point will be seen as being in focus. For the sake of discussion, consider this distance as being an object in the crime scene 20′ from the camera. Light coming from a distance of about 24′ will not intersect at the sensor. It will actually intersect **before** the sensor, cross over, and continue until it strikes the sensor as a small circle. Imagine this small circle as the left shaded circle in Fig. 5.15. Light coming from a distance of 18′ will not intersect at the sensor. If it could, it would intersect behind the sensor. At the sensor, it is still a circle. Imagine this small shaded circle as the right shaded circle in Fig. 5.15.

DOF is the range, in front of and behind the plane of exact focus, of what also appears to the eye to be in focus. Therefore, not only will the item at 20′ appear in focus, but also anything between 18′ and 24′. Anything closer than 18′ and anything beyond 24′ will appear to be out of focus because at the sensor they would create a circle of confusion **larger** than what the resolution limit of the eye will detect as being in focus. These distances are depicted as clear ellipses in Fig. 5.15. If light forms a circle larger than 0.025″ to 0.033″ on the film plane, the image at those distances appears to the eye to be "confused" or blurred.

In Fig. 5.15, the light is coming from the extreme edges of the lens, intending to suggest the widest aperture of the lens. Consider this aperture to be f/2 for the time being. What would occur if the light entered the lens when a smaller f/stop is being used? Fig. 5.16 shows this situation. The shaded circles of confusion are the same size in both Figs. 5.15 and 5.16.

Notice that as the aperture becomes smaller, from f/2 to f/22, the circles of confusion, perceived by the eye to be in focus, move further away from the film plane, which is the explanation for the larger DOF produced by using smaller apertures. Fig. 5.15 shows the equivalent of an f/2 aperture. Fig. 5.16 shows the equivalent of perhaps an f/11 aperture. The use of an f/11 would give the appearance to the eye as having more in focus. In this case, the DOF range would be something like 12′ to 36′ when focused on 20′.

One of the camera's variables that affect DOF is the f/stop selection. With this information, let us return to the DOF scale in Fig. 5.14. The DOF scale is designed to be used in conjunction with the distance scale. The DOF scale is composed of pairs of f/stop numbers radiating outward from the point of exact focus. Some lenses do not show as many f/stop numbers as are depicted in Fig. 5.14. Some lenses do not have a DOF scale at all. Fig. 5.14 is a good training tool to explain DOF.

Once the f/stop for a proper exposure has been determined, the photographer can then refer to the DOF scale to determine exactly how much of the crime scene will be in focus when the image is printed. With the top image of Fig. 5.14A, it is evident that the photographer has focused at about the 12′ distance (follow the orange line up to the green distance scale). Aligning the DOF scale with the distance scale, the photographer can then see what the DOF range will be. The distance that falls between the pair of f/stop numbers on the DOF scale is the DOF range. With each f/stop, then, you see the following DOF ranges, when the camera is focused at 12′:

1. f/22: 6′ to ∞
2. f/16: 7′ to 30′
3. f/11: 8′ to 25′
4. f/8: 9′ to 20′
5. f/5.6: (not shown)
6. f/4: 10′ to 14′

Wider apertures result in narrower DOF ranges; smaller apertures result in progressively longer DOF ranges.

The DOF scale is a great tool if you have it. But, what if your lens does not have a DOF scale? Here is how to hyperfocal focus without a DOF scale. To begin, consider the images in Fig. 5.14 again.

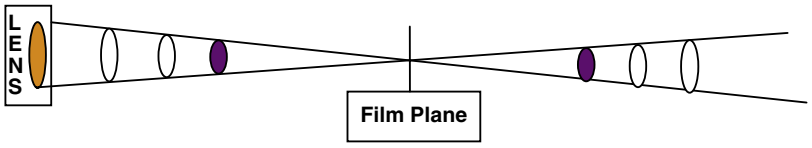


FIGURE 5.16
Circles of confusion, small aperture.

Table 5.1 Hyperfocal Focusing Ranges

F/stop	Depth of field range
F/22	6′ to ∞, when focused at 12′
F/16	8′ to ∞, when focused at 16′
F/11	12′ to ∞, when focused at 24′
F/8	15′ to ∞, when focused at 30′

The Fig. 5.14B shows one way to ensure infinity will be in focus. Simply focus on the infinity symbol. Now, by use of the DOF scale, you can determine what will be in focus when the print is made. If the lighting enables an f/22 to be used for a proper exposure, the distances between the two 22s will be in focus when the print is made. The Fig. 5.14B shows this to be 12′ to infinity. Not bad. Notice all the distance between the infinity symbol and 22 on the **right side** of the DOF scale, which is, in effect, wasted DOF.

Hyperfocal focusing is the technique to maximize the DOF, when infinity is in the field of view. To hyperfocal focus, first determine the f/stop required for the lighting at the scene. Once the f/stop has been determined, align that f/stop, on the DOF scale, with the infinity symbol on the distance scale. Presume it is a bright sunny day, and the meter reading indicates an f/22 can be used to properly expose the scene. The Fig. 5.14A shows the result. The infinity symbol is now aligned with the right 22 on the DOF scale. The DOF range will be the distance between the two 22s as they align with the distance scale. The Fig. 5.14A indicates the new DOF range is 6′ to infinity. That is a net gain of 6′ that will be in focus when the image is printed.

With both focusing techniques, infinity will be in focus. With hyperfocal focusing, you have also maximized the DOF. Hyperfocal focusing increases the DOF range in the foreground.

No other focusing technique will provide better DOF when infinity is in the background.

Let us also examine the hyperfocal focusing range with f/16, f/11, and f/8. This may perhaps be best understood in Table 5.1. The four images of Fig. 5.17 show the result of hyperfocal focusing with an f/22, f/16, f/11, and f/8.

Notice that the point of exact focus, the **Hyperfocal Focusing Distance**, is always double the short end of the DOF range. We will use that fact momentarily.

Having a lens with a DOF scale is certainly very convenient. However, as mentioned earlier, many recently manufactured lenses do not have this handy tool. In many situations having a DOF scale would make the job easier on crime scene photographers. It comes down to this: is there a way to hyperfocal focus without a DOF scale? Yes.

Lens construction standards are so uniform that even if your particular lens does not have a DOF scale, you can still use the theory of hyperfocal focusing to maximize your DOF when photographing large exterior crime scenes when infinity is in the background. How? First, determine the f/stop required for the lighting of your scene. Then focus at one of the following distances appropriate for your f/stop (again, see Fig. 5.17. Notice the point of exact focus for each of them.):

- If using an f/22, focus the lens at 12′.
- If using an f/16, focus the lens at 16′.
- If using an f/11, focus the lens at 24′.
- If using an f/8, focus the lens at 30′.

This is important enough to **memorize** which distances to focus at for the f/stop required for the lighting at the scene.

You can focus the lens by using the distance scale, by aligning the focusing point of the lens with the correct distance on the distance scale. Or, you can find a surrogate item somewhere in the crime scene the prescribed distance you need and focus at it. Remember, hyperfocal focusing is the optimal focusing technique for this particular focusing situation. Any other focusing technique will result in either the background (∞) being out of focus or less of the foreground being in focus. Neither of these options is desirable.

Why are hyperfocal focusing ranges for the other f/stops not provided? Remember, these are images of large outdoor crime scenes, when it is necessary to have infinity in the field of view. Using wider apertures results in a smaller DOF range, making it more difficult to have any evidence relatively close to the camera be in focus while maintaining infinity in focus at the same time.



FIGURE 5.17
Hyperfocal focused.

Some writers feel the DOF scale on lenses does not really ensure that the DOF range indicated as written above will truly be in focus. Here is a recommendation. With your particular camera and lens, set up a series of test distances. Test the f/22 hyperfocal focusing range by placing objects 6′, 8′, and 10′ from the camera. Focus at 12′. Take the photograph. When the photograph is printed, check to see whether the object at 6′ looks to be a bit "soft" or slightly out of focus. If so, it is hoped the object at 8′ looks sharp. If the object at 8′ looks sharper than the object at 6′ just bump up the hyperfocal focusing recommendations one notch.

- Consider the f/22 DOF range to be 8′ to ∞ when focused on 12′.
- Consider the f/16 DOF range to be 12′ to ∞ when focused on 16′.
- Consider the f/11 DOF range to be 15′ to ∞ when focused on 24′.
- Consider the f/8 DOF range to be 20′ to ∞ when focused on 30′.

The preceding description effectively "calibrates" the hyperfocal focusing concept for your specific camera and lens.

Zone Focusing

Infinity is not always in the background of outdoor crime scenes. An obstruction, like the wall of a building, may be present 30′, 40′, or 50′ from the camera. If, when you look through the viewfinder, infinity is not in the background, hyperfocal focusing is not applicable. How do you maximize the DOF when infinity is not an issue?



FIGURE 5.18
Zone focusing: top 30′ away.

For instance, on a bright sunny day, you may want to photograph a scene between you and a wall about 30′ away. Nothing in the field of view will be farther away than the 30′ distance of the wall. Now, it is **not** important to ensure that ∞ is in focus. You just need to ensure the wall, as the background of the photograph, is in focus.

Zone Focusing is the technique to maximize the DOF for an **area** when infinity is **not** in the background. The zone focusing technique is a bit like the hyperfocal focusing technique. This technique also relies on your lens having a DOF scale. As in the hyperfocal focusing technique, the first step is to determine the f/stop required for the lighting at the scene, which is done by simply taking a meter reading of the crime scene. The second step is to determine the distance of the background of this particular crime scene, which may be a real obstruction, like a wall, or it may be the distance from your camera you decide will be the top of your field of view when you compose this image. Look at Fig. 5.18.

Fig. 5.18 shows the scene, with the top of the image, the wall, 30′ from the camera. In this case, it is not necessary to have anything beyond 30′ be in focus.

With zone focusing, it is necessary to determine the distance of the background. Manually focus on the wall to determine its exact distance. Focus on the wall and then look at your distance scale and note the distance shown. Had your crime scene been the one shown in either Fig. 5.18, this distance would be 30′.

If no wall or other fixed object is in the background, determine the distance of the top edge of your composition. Consider Fig. 5.18. Make a mental note of what is at the top of your composition; then swing your camera up so that area is now in the center of your viewfinder, and manually focus the camera. To make this easier, consider the previous suggestion to use the telephoto end of your zoom lens. Set the focal length to your lens' most extreme telephoto focal length. For instance, if your zoom lens has a 28 to 105 mm zoom range, set the lens to 105 mm. That will magnify all areas in your viewfinder. Focus at the distance that will eventually be the top of your composition when viewed with a 50 mm lens setting. Check the distance scale of your camera to see the exact distance of this area. Again, if Fig. 5.18 was your crime scene, 30′ should show on your distance scale. That distance will then be aligned with the f/stop required for the lighting of the scene on the DOF scale.

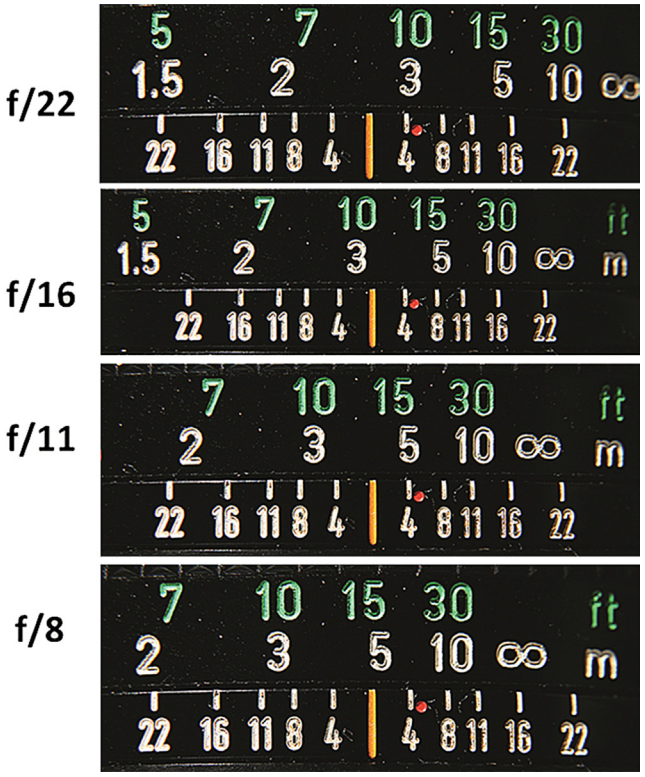


FIGURE 5.19
Zone focusing.

If the lighting will permit the use of an f/22, align the right 22 over the 30′ mark. See Fig. 5.19 for the alignment of the DOF scale and the distance scale to zone focus at 30′ with f/22, f/16, f/11, and f/8.

- If the lighting requires an f/22, the DOF range is 5′ to 30′.
- If the lighting requires an f/16, the DOF range is 6.5′ to 30′.
- If the lighting requires an f/11, the DOF range is 9′ to 30′.
- If the lighting requires an f/8, the DOF range is 11′ to 30′.

In each of these lighting conditions, it would be important to make sure the bottom edge of your photograph does not include anything in the field of view in front of the short end of your DOF range.

- If using an f/22, do not include detail before 5′.
- If using an f/16, do not include detail before 6.5′.
- If using an f/11, do not include detail before 9′.
- If using an f/8, do not include detail before 11′.

Simply compose your image so the bottom of your field of view matches the short end of your DOF range, which you do by raising and lowering your camera while you look through the viewfinder.

No other focusing technique maximizes the DOF better when it is not critical that infinity be in focus.

You may now be imagining a situation in which raising the camera to one of these prescribed near-end distances forces the top edge of the field of view to include more than the 30′ we began this discussion with. Aligning the top of the field of view at 30′ may force more into the near end of the field of view than the preceding distances. What to do then? These situations may occur at real crime scenes, depending on the lighting at the scene. Although it is a Cardinal Rule to attempt to maximize the DOF at all times, nothing guarantees that everything in your field of view will be in focus for every image you capture. That is the goal, and sometimes this goal is not achievable, particularly when the lighting becomes dimmer. The question remains: what should you do? If the choice is between obviously out-of-focus foreground and obviously out-of-focus background, this author usually opts for the out-of-focus background because it is slightly less noticeable.

Focusing by the Rule of Thirds

What if your camera equipment does not have the DOF scale on the lens? Many lenses do not have this feature. How should you zone focus then?

First, be aware that the DOF range is not usually the same in front of and behind the plane of exact focus. For instance, if you are focused on a point 10′ from the camera, while using an f/16 for the lighting, the DOF range will be almost 14′ in total. This 14′ is not divided by 2 resulting in 7′ in front of the 10′ focus point being in focus, and 7′ behind the 10′ focus point being in focus. It certainly would be nice if this were the case, but it is not the case. Usually, more of the DOF range exists behind the point of exact focus than in front of it.

At this point, many other authors insert a dictum that the DOF range extends one-third of the total range in front of the point of exact focus, and two-thirds of the total range behind the point of exact focus. In fact, this is often presented as a Rule of Thumb.

RULE OF THUMB 5.3

The depth of field usually extends one-third in front of the point of exact focus and two-thirds behind the point of exact focus.

Although this is a handy rule of thumb in some circumstances, it is certainly incorrect in many instances.

In all hyperfocal focusing situations, you can immediately see that the DOF range behind the point of exact focus is much more than double the DOF range in front of the point of exact focus. Recall that an f/22 will result in a DOF range of 6′ to infinity when focused at 12′. That is 6′ in focus in front of the exact point of focus and 12′ to infinity in focus behind the point of exact focus. Certainly not a one-third and two-thirds ratio.

When you are zone focusing with background distances at 30′ or beyond, it is again clear that a one-third and two-thirds ratio does not apply. See Fig. 5.19 again. With an f/22, the DOF range is 5′ to 30′ when focused at 9′. That is 4′ in front of the point of exact focus and 21′ behind the point of exact focus: almost a one-sixth and five-sixths ratio.

However, when the maximum background distance in the field of view is reduced to between 5′ and 20′, the one-third and two-thirds ratio is pretty closely approximated.

When closer than 3′, the ratio approaches ½ and ½. This is certainly the DOF ratio for **all** close-up photographs. As much will be in focus in front of the plane of exact focus as will be behind it. This point is extremely important to remember if you photograph fingerprints on a curved surface. Do not be misled by the Rule of Thumb, one-third and two-thirds DOF range, in this situation.

Finally, if you take many photographs through a microscope, you should know that the DOF range changes again, and this time the DOF range approaches two-thirds in **front** of the plane of exact focus and just one-third **behind** the plane of exact focus.

Back to the Rule of Thirds as a focusing technique: This author has crunched the numbers at each distance between 3′ and 30′ and with the f/stops f/8 through f/22. The results follow. Do not be too concerned with these numbers and percentages. You do not need to memorize them. A very easy method to zone focus will soon be indicated. This information is presented to further indicate that the one-third and two-thirds ratio of the area in focus around the point of exact focus is not very precise.

- If 30′ is the background distance, the average ratio of foreground-to-background area in focus is 20% in front and 80% behind.
- If 20′ is the background distance, the average ratio of foreground-to-background area in focus is 28% in front and 72% behind.
- If 15′ is the background distance, the average ratio of foreground-to-background area in focus is 28% in front and 72% behind.
- If 10′ is the background distance, the average ratio of foreground-to-background area in focus is 36% in front and 64% behind.
- If 5′ is the background distance, the average ratio of foreground-to-background area in focus is 40% in front and 60% behind.

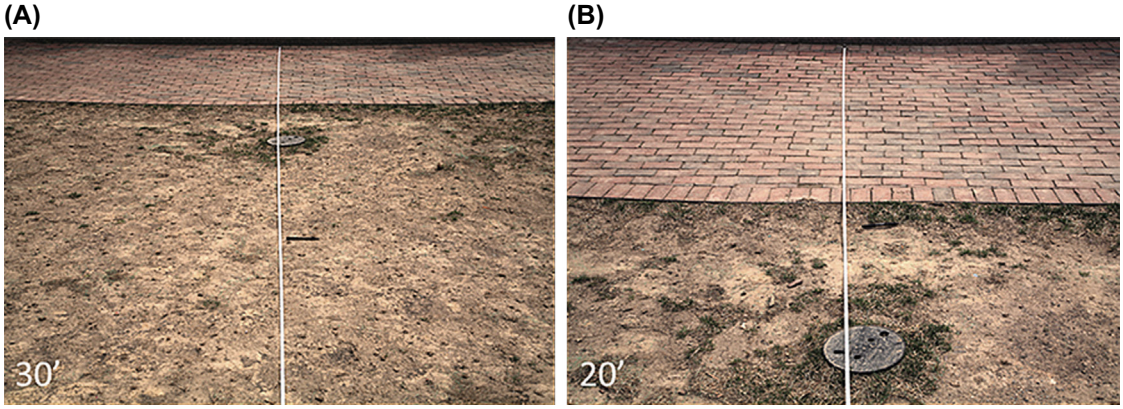


FIGURE 5.20
(A) Zone focused at 30′. (B) Zone focused at 20′.

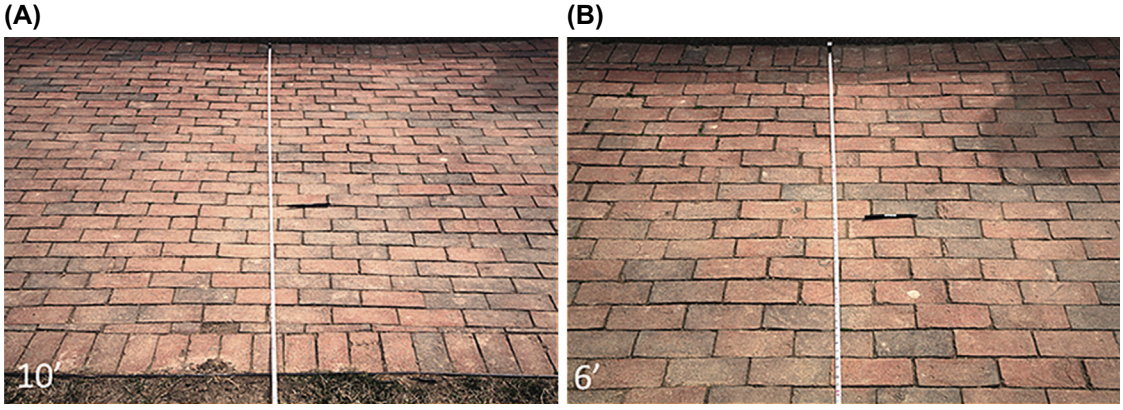


FIGURE 5.21
(A) Zone focused at 10′. (B) Zone focused at 6′.

How does this information help you zone focus if your lens does not have a DOF scale? Representative images of each of the preceding scenes will make it more obvious; see Figs. 5.20 and 5.21.

In each of these images, a pen was placed at the prescribed distance indicated in the preceding list. Even as the precise ratio of what is in front of the plane of exact focus and what is behind the plane of exact focus changes with each distance, one very obvious similarity exists in each of the photographs. The pen appears to be positioned at approximately the midpoint of each image. The pen actually appears to be positioned halfway between the **top** of each image and the **bottom** of each image. This is not necessarily halfway between the foreground and the background in each image.

How can you put this information to use at crime scenes?

If you have a DOF scale, use it. That is the easiest way to maximize the DOF whether you are hyperfocal focusing or zone focusing. But if you are in a zone focusing situation, and your lens does not have a DOF scale, the quickest, most accurate method of focusing to maximize the DOF is to focus at the distance that is midway between the **top** of the composed image in the viewfinder and the **bottom** of the composed image in the viewfinder.

Crime scene photography is already a very stressful situation. Rather than making crime scene photography procedures more difficult, a good text should make them easier to understand and apply. The best way to zone focus is to focus at a distance that appears to be midway between the **top** and **bottom** of the composed image. Let us make this a revised Rule of Thumb.

RULE OF THUMB 5.4

When you are attempting to maximize the depth of field with crime scenes ranging from 5′ to 30′, the most effective way to do this is to focus at a distance that appears to be midway between the top and the bottom of the composed image in the viewfinder.



FIGURE 5.22
Diopter dial.

Out-of-Focus Images

It is unusual to teach a course on crime scene photography without receiving several out-of-focus photographs from a student. When this fact is pointed out to the student, and they are asked to retake the photographs, the photographs sometimes come back out-of-focus again. It becomes clear that this student is unaware his/her vision needs correction. If the student has never seen anything with clear, sharp focus, that student does not know the difference and turns in what looks to be the best to them. However, over the years, several students have tried to defend their out-of-focus photographs by suggesting the problem must have been an "equipment malfunction."

This section describes how the conflict can be resolved. The student is set up with a digital SLR camera on a tripod, with the film plane parallel to the object they have had trouble with. The student is asked to manually focus the camera as best they can and take the photograph. With the camera in the same position, the student is told to switch to the autofocus mode and to press the shutter button down halfway and listen closely to determine whether they can hear the camera readjust focus. The student then captures that image. Comparing the two images usually can convince the student that focusing by eye results in an out-of-focus image, whereas the camera's autofocus results in a better image. Solution: the student is told to get glasses or have current prescriptions updated.

Sometimes a student swears their vision is good, but whenever they look through the camera viewfinder, everything always looks blurry. This may actually happen for a very good reason. They have not yet adjusted their diopter adjustment dial for their own eyesight. It is usually located just to the right of the viewfinder (see Fig. 5.22). It may be a dial or thumb slide that moves up and down. In either case, it allows you to adjust the viewfinder for your own eyes. Usually, it is recommended to look through the viewfinder, select a ceiling or a blank wall, and notice the focus rectangle or circle in the middle of the viewfinder. While looking through the viewfinder, adjust the diopter dial to get the rectangle or circle in focus as best you can. At some point, it should look tack sharp.

Using this diopter adjustment dial is, more or less, the equivalent of trying on various strengths of reading glasses and is often the solution to some focusing issues.

DEPTH OF FIELD

Factors Affecting Depth of Field

Three camera variables directly affect the DOF range. They are:

- F/stop choice
- Lens choice
- Camera-to-subject distance

We will examine each in turn.

F/Stop Selection as a Depth-of-Field Variable

As previously explained, f/stops are a primary exposure control. Along with shutter speeds and ISO selections, they are one of three primary camera controls that affect exposures.

In addition to being an exposure control, f/stops also are one of the camera variables that directly control the DOF range. This fact cannot be overemphasized. DOF, by definition, is the variable range, from foreground to background, of what appears to be in sharp focus.

When considering DOF, remember that it is possible to maximize the DOF range, and it is possible to minimize the DOF range. Obviously, because one of the Cardinal Rules is to maximize the DOF as much as possible, that is the main concern with crime scene photography.

However, understanding the effect of minimizing the DOF range is valuable. This text will offer two situations illustrating when minimizing the DOF will be the goal of the crime scene photographer. One relates to intermediate objects/obstructions between the photographer and the subject matter considered the primary subject. In such a situation, if the photographer can create a small DOF range and place it on a distant subject, intermediate details will fall outside the DOF range and become blurred and out of focus. This intentional blurring of intermediate detail can be so pronounced as to make the intermediate detail so blurred as to become almost invisible. Making an intermediate obstruction so blurred as to become almost invisible allows you to see the primary subject better.

In another situation, the background of an image may be detracting from an item of evidence in the foreground. Blurring the background, by creating a small DOF range, when focused on the foreground can make a great improvement on the image.

These two situations when minimizing the DOF range is a clear advantage are as follows:

- In daytime surveillance situations, positioning the camera behind a bush or other obstruction is necessary to prevent the photographer from being seen by the subject of the surveillance. In this case, having the bush in front of the camera is both good and bad. It is a good visual obstruction in that it makes it difficult or impossible for the subject of the surveillance to see the photographer. It can be bad if the same bush makes it difficult for the camera to acquire a good image of the subject of the surveillance. See the images in Fig. 5.23.



FIGURE 5.23
Minimizing the depth of field to photograph a license plate.

- At a crime scene, a latent print is powder processed and visualized on window glass. Before lifting this print, it is decided to photograph it first. When composing a close-up photograph of the latent, it is noticed that details outside appear behind the fingerprint, making the fingerprint ridge detail difficult to see. If the details outside can be blurred by minimizing the DOF, then the print will be more clear and easier to see. If that, by itself, is not enough, then just a bit of Photoshop processing may be required. See both images of Fig. 5.24. Fig. 5.24, left, is an attempt to blur the background to improve the view of the fingerprint. Fig. 5.24, right, is a Photoshop-processed image of the same fingerprint.

What is the effect of using a wide aperture? With a wide aperture, the DOF range can be very short. One object/person can appear to be in focus, with everything else, both in front of and behind that object/person, appearing to be out of focus. This short DOF range can be placed in the foreground, in the mid-ground, or in the background. Wide apertures, like those produced with f/2, f/2.8, and f/4, create very short ranges of DOF.

Fig. 5.25A shows the effect of using an f/1.8, a very wide aperture, while focusing on the #1 in the photograph. The #1 is obviously in focus, whereas the focus quickly deteriorates behind the #1. Fig. 5.25B moves the point of focus to the #2. Now, both #1 and #3 appear "soft" or out of focus. Fig. 5.26A moves the point of focus to the #3. Both #1 and #2 now appear "soft" or out of focus.

Fig. 5.26B shows the effect of using an f/22, a very small aperture, on the same scene. Through the use of zone focusing, the entire area appears to be in focus. All three numbers are sharp. Fig. 5.27 makes the same point. With a wide aperture, the DOF range can encompass just one item, like the balls in the top-left, top-right, and lower-left images. With a small aperture, like f/22, the DOF range can encompass almost everything in the field of view, like the lower-right image.

Recall Figs. 5.15 and 5.16. When the aperture is wide, the circles of confusion perceived by the eye to still be in focus are relatively close to the point of exact focus. The DOF range, then, will be very small. When the aperture is very small, the circles of confusion perceived by the eye to still be in focus are relatively far apart. The DOF range, then, will be very long.

With either wide or narrow f/stops, you would be able to focus on an object/person at any distance, and they would be in perfect focus in the resulting photograph. As the two graphics show, with either a wide or narrow f/stop selection, the light rays can be brought into focus where the lines meet at the film plane. As the light rays travel from the lens opening, on the left, to the point of perfect focus, they are converging down their respective cones, until the light rays meet at the film. At the film plane, the light rays are in perfect focus.



FIGURE 5.24
Fingerprint on window glass, captured with the widest aperture.

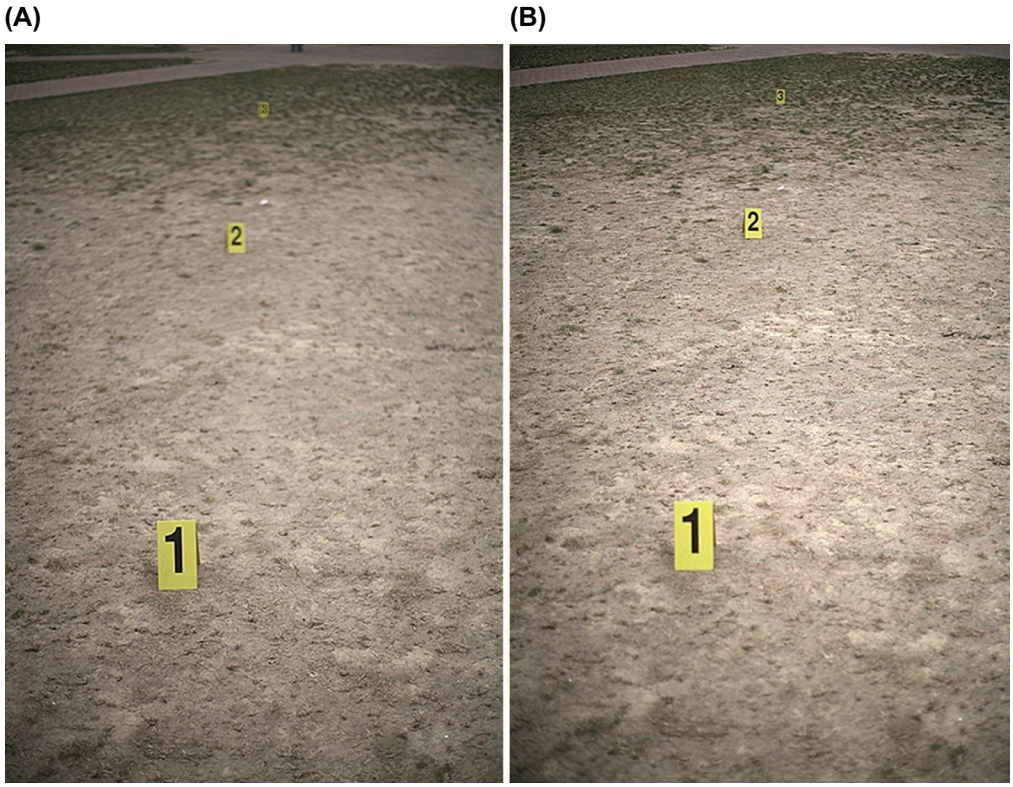


FIGURE 5.25
(A) Focused on #1. (B) Focused on #2.

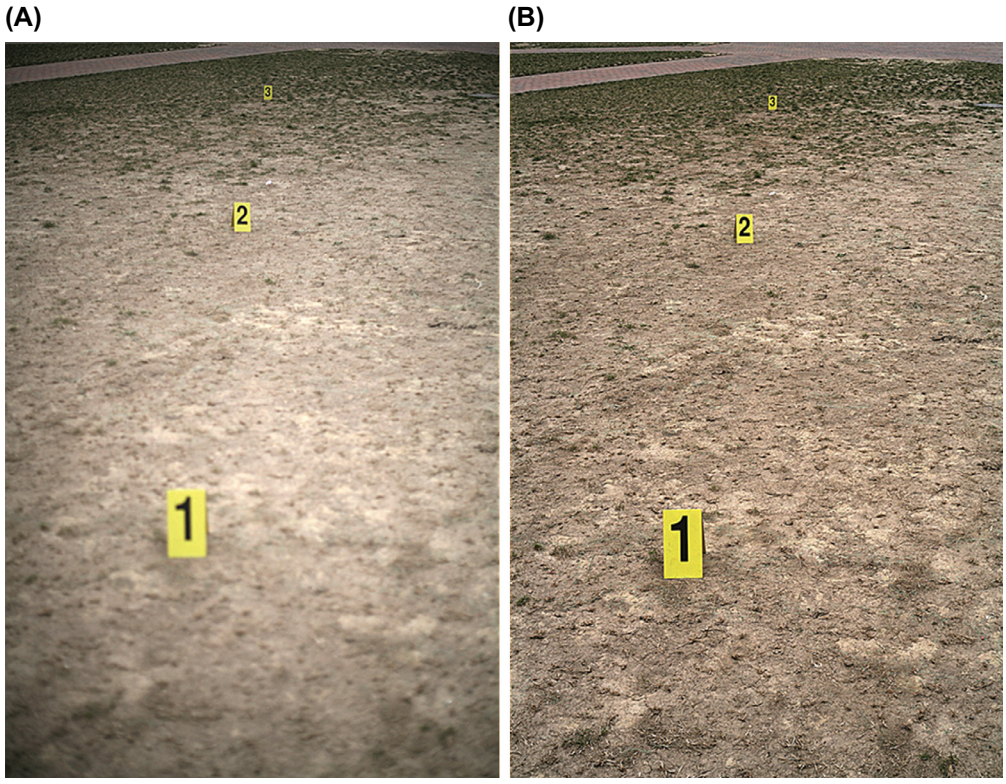


FIGURE 5.26
(A) Focused on #3. (B) Zone focused with f/22.

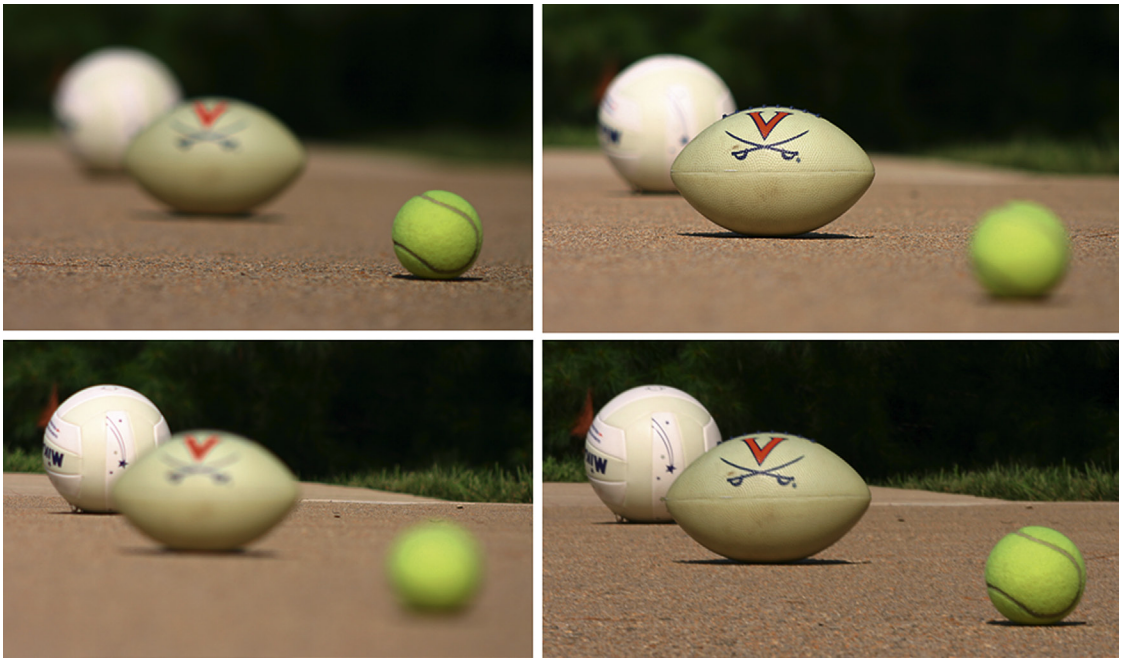


FIGURE 5.27
Varying depth-of-field ranges.
Courtesy of Denise Sediq, GWU MFS student.

The DOF range will increase as f/stops are changed, moving on a continuum from f/2 to f/22. F/stops representing large lens openings produce relatively short DOF ranges, and f/stops representing small lens openings produce relatively long DOF ranges. This is purely a function of the way the lenses bend light to converge at the film plane and the relative distance of the circles of confusion, still appearing to be in focus to the eye, are from the point of exact focus at the film plane.

In summary, considering an f/stop range from f/2 to f/22, which is common with many lenses, the f/2 results in the shortest DOF range. The DOF range progressively increases as you move toward the f/22 lens opening.

Lens Choice as a Depth-of-Field Variable

How can the lens choice affect the DOF? Examine Fig. 5.28.

The f/stop number has a relationship to the focal length of a lens. This equation shows the relationship: FLL/f-stop = DOD, where,

- FLL equals the focal length of the lens.
- F/stop is the particular f/stop number.
- DOD is the diameter of the diaphragm or the size of the lens opening.

This equation can also be written as either FLL/DOD = f/stop, or DOD (f/stop) = FLL.

1. The diameter of the diaphragm can be determined by dividing the FLL by the f/stop.
2. The f/stop number comes from dividing the FLL by the size of the lens opening.
3. The FLL is the product of multiplying the f/stop number and size of the lens opening.

The graphic in Fig. 5.28 is a visual demonstration that, at any f/stop, wide-angle lenses will have a better DOF range than "normal" lenses, and "normal" lenses will have a better DOF than telephoto lenses.

Another way of saying this is to state that the **same** f/stop number will result in **different** lens apertures/openings, depending on which focal length of lens is being used.

To make this clear, let us begin by examining an f/stop of f/8. Notice the relative DODs that result with different lenses. In the example in Fig. 5.28, lenses of 24, 50, and 100 mm are compared, but the theory would hold for any lenses.

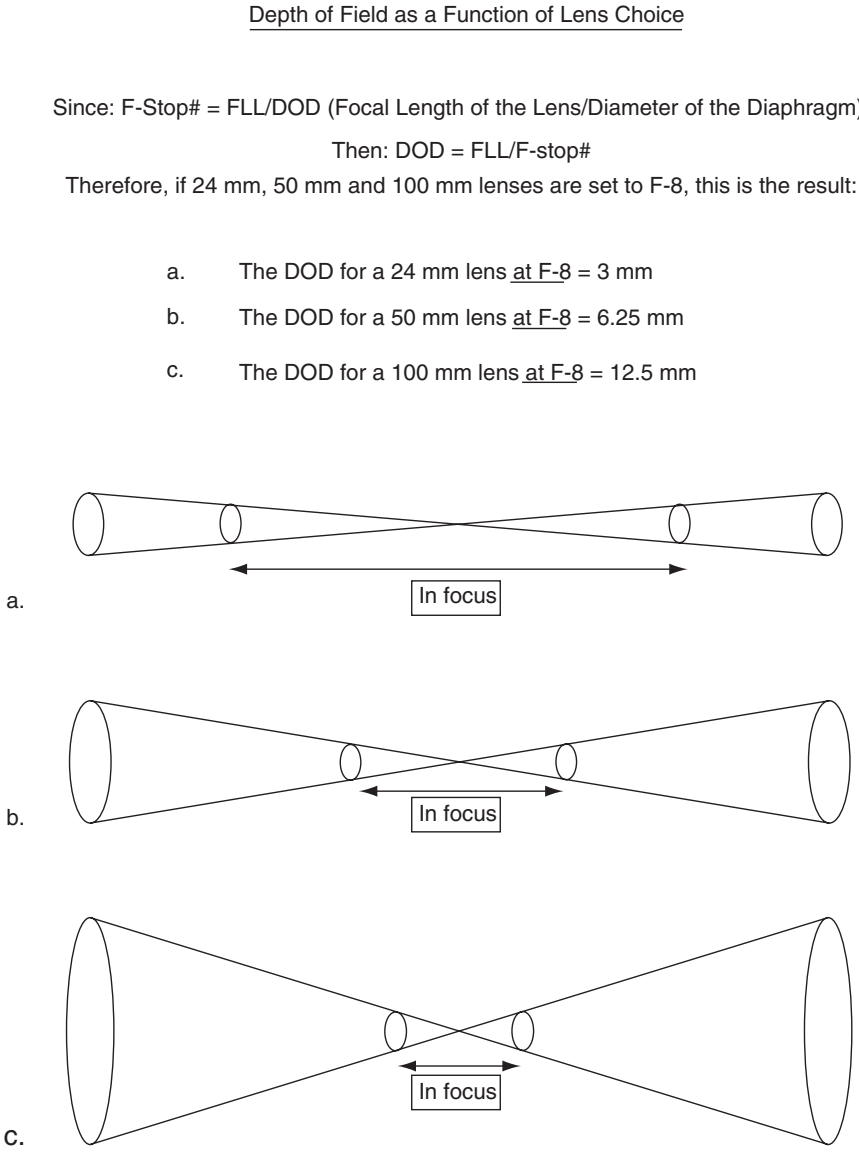


FIGURE 5.28
Depth of field as a function of lens choice.

- The DOD for a 24 mm lens, set at f/8, would be 3 mm: FLL/f/stop = DOD, or 24/8 = 3 mm.
- The DOD for a 50 mm lens, set at f/8, would be 6.25 mm: FLL/f/stop = DOD, or 50/8 = 6.25 mm.
- The DOD for a 100 mm lens, set at f/8, would be 12.5 mm: FLL/f/stop = DOD, or 100/8 = 12.5 mm.

Because the DOD of each lens is a different size, as light travels from the front of the lens and diaphragm opening to the sensor, figures similar to the graphic are produced. Even though the same f/stop has been selected for all three focal lengths, the effective size of the lens opening to the light that will be entering the camera will change. As already determined with the examination of f/stops, the DOF range is improved with smaller lens openings, which is shown by the pairs of small ellipses shown in all three examples. They represent the circle of confusion perceived by the eye to still be **in focus**. In each example, the pairs of small ellipses appear to be different distances from the point of exact focus or the point where the lines intersect in the middle of each figure. As the ellipses get further apart, the DOF range increases.

Therefore, because wide-angle lenses produce smaller lens openings than "normal" and Telephoto Lenses, the resultant DOF range will be greater. Because "normal" lenses produce smaller lens openings than Telephoto Lenses, their resultant DOF range will be greater.

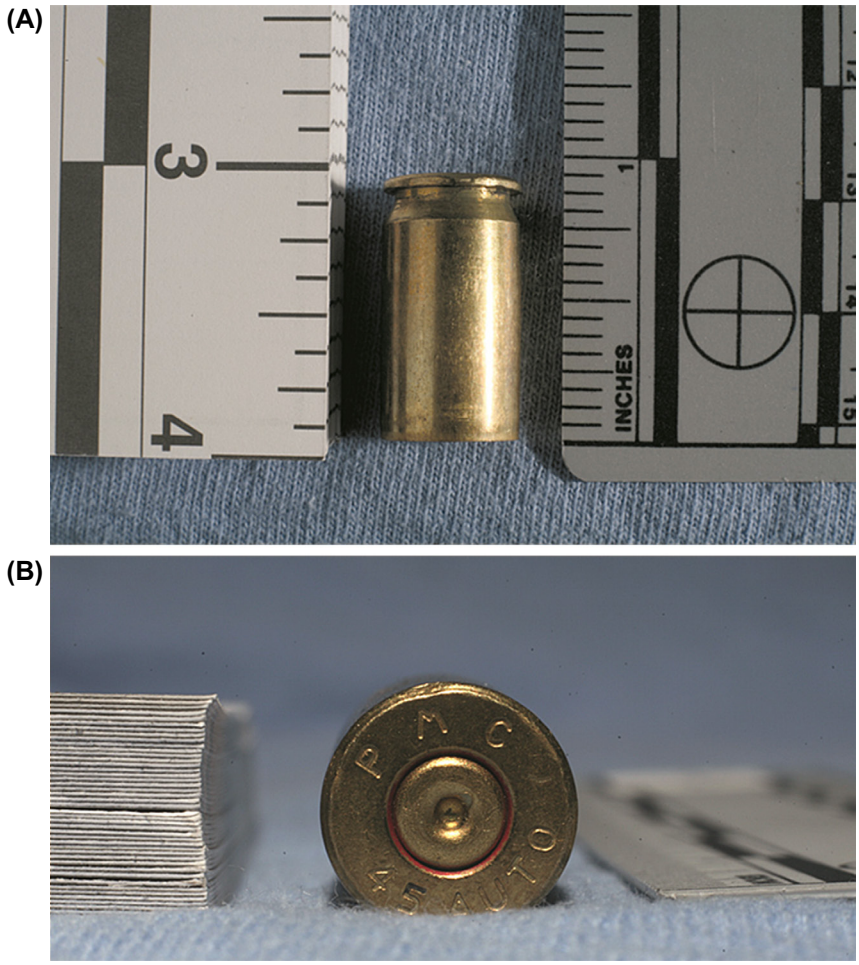


FIGURE 5.29
(A) 0.45 casing with two scales. (B) Scales viewed from a low viewpoint.

Camera-to-Subject Distance

How can camera-to-subject distance affect DOF? As you will recall, through the use of hyperfocal focusing with an f/22, the resulting DOF range is 6′ to infinity. No other f/stop will provide more DOF when hyperfocal focusing. When you are zone focusing with a background of 30′, that same f/22 will result in a DOF range of 5′ to 30′, quite a substantial reduction in the DOF range. When you are zone focusing with a background of 10′, that same f/22 will result in a DOF range of 3.8′ to 10′. Again, the DOF range has been reduced. Let us jump to a situation in which you need to capture a close-up photograph of a 0.45-caliber cartridge casing at a crime scene. Using close-up equipment, which will be explained later in this chapter, you can fill the frame with the cartridge casing. An f/22 can also be used in this situation. You would expect a pretty good DOF by using the f/22, would you not? If you find yourself nodding in agreement to that last sentence, you would be wrong.

A 0.45-caliber cartridge casing is 45/100″ wide, or just shy of ½″. That means the surface the casing is sitting on is 24/100″ farther from the sensor than the top of the casing that is being focused on. Surely, the DOF range with an f/22 would cover this distance. Wrong again.

Fig. 5.29A shows a 0.45-caliber cartridge flanked by two scales. The scale on the left has been raised up to the level of the top of the casing; the scale on the right has just been laid next to the casing. Fig. 5.29B shows the same positioning of scales, but this viewpoint makes the difference in height between the two scales clear. As you examine Fig. 5.29A more closely, do you notice any difference in the two scales? If you have very good eyes, you might notice that the word "inches" appears a bit "soft" or slightly out-of-focus. Why? Because the DOF range in a close-up situation like this is less than the ½″ difference between the top of the left scale and the right scale.

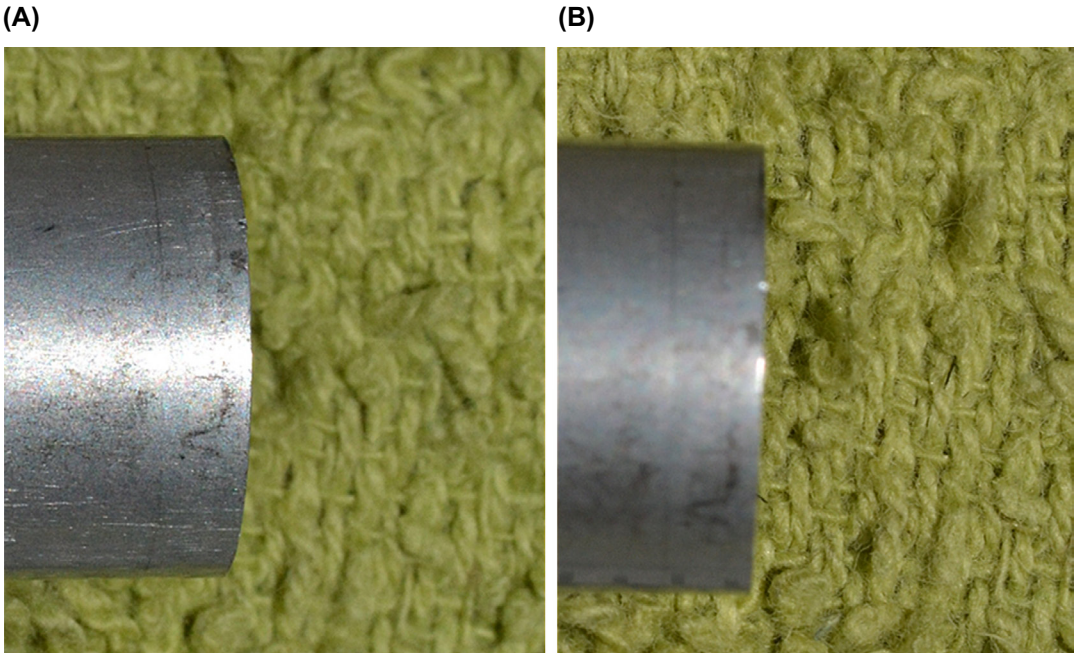


FIGURE 5.30
(A) Focused on the top of the casing. (B) Focused on the fabric.
Courtesy of GWU MFS student J. Wreh.

Let us make this more obvious with more extreme close-ups of another 0.45-caliber casing. The photo in Fig. 5.30A shows the mouth of the casing and the background fabric. Various stria are plainly visible on the mouth of the casing because focus was adjusted for the top of the casing. Notice in this image that the fabric is more obviously "soft" from being a bit out of focus.

But in Fig. 5.30B, the focus was adjusted to the surface of the cloth. Now, the fabric is much sharper, but the stria on the mouth of the casing have become blurred. Why? The difference is simply that the DOF range with an f/22 does not encompass both distances when close-up photographs are taken.

An f/22 can provide a DOF range of 6′ to infinity when you hyperfocal focus, and this same f/22 has less than a ½″ DOF range when extreme close-ups are taken. This should make you extremely cautious whenever you take close-up photographs, and this caution is well deserved. As you get closer and closer to your subject matter, the DOF range begins to collapse.

It would now be good to relate two seemingly unrelated topics: focusing on infinity and close focusing on small objects. They are related. Focusing on infinity wasted DOF in the foreground; hence, the recommendation is to hyperfocal focus instead. Both focusing on infinity and hyperfocal focusing ensured infinity would be in focus. What is the practical difference? Hyperfocal focusing provided for more focus in the foreground.

With Fig. 5.30 still fresh in your mind, you may see the link and realize that focusing on top of any cartridge casing may actually be wasting some of the available DOF range. If, in fact, the DOF range for extreme close-ups is less than ½″ in front of the plane of exact focus and ½″ behind the plane of exact focus, then focusing on top of the cartridge casing wastes some of the DOF range! It would actually be more effective to focus a little down the side of the cartridge casing. That way, the near DOF range could include the top of the casing, and the far DOF range would proceed further down the casing, which would be extremely relevant when a fingerprint is on the cartridge casing and you want to make sure as much of the fingerprint on the same casing is in focus as possible, which would also be applicable whenever any critical evidence is on a curved surface and maximizing the DOF range is important. In these situations, bracketing by changing the focus point instead of the exposure value would be warranted. But, certainly, just automatically focusing on the top of the cartridge casing, as crime scene photographers are all instinctively prone to do, would actually be counterproductive if you wished to maximize the DOF for a close-up image.

Tips to Maximize Depth of Field

The DOF is the variable range, from foreground to background, of what appears to be in acceptable focus. That is its definition. When you are photographing crime scenes, accident scenes, and the evidence within those scenes, can you think of any time, which has not already been covered in this chapter, when you would intentionally want part of those photographs to be out of focus? For the most part, you should follow the Cardinal Rule: Maximize DOF whenever possible. An out-of-focus photograph may not be acceptable in court as evidence, which will be emphasized again when legal matters concerning photographs are discussed. However, this point cannot be overstated: maximizing the DOF should be one of your constant concerns when engaged in crime/accident scene and evidence photography.

Here are several techniques to ensure the DOF is maximized. We have already dealt with three of them.

1. Hyperfocal focus when taking photographs of large outdoor crime scenes when infinity is in the background.
2. Zone focus when taking photographs of large crime scenes but infinity is not in the background, which will require having a DOF scale.
3. Focus by the rule of thirds when taking photographs of large crime scenes when infinity is not in the background, and you do not have a DOF scale.

A few more ideas will help ensure the DOF is maxed out most of the time.

4. Select the ISO film speed/digital equivalent to maximize the DOF.

Because the f/stop selection is one of the critical factors affecting the DOF, and the small f/stops (f/22, f/16, f/11, and f/8) always provide for better DOF ranges than the wide f/stops (f/2, f/2.8, f/4), how do you choose an ISO that will ensure the use of these smaller apertures? With digital cameras, there is no cost to varying the ISO selections. So, what is the slowest ISO that will allow photography with the small apertures?

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On bright sunny days, ISO 100 will allow photography with the smaller f/stops. Otherwise, on cloudy or dark days, at nighttime, or indoors when using electronic flash, use a faster ISO like ISO 400.

With the steady trend toward digital imaging at crime scenes, all crime scene photographers will now have digital 35 mm SLR cameras as their standard tool and will be able to select any ISO film equivalent for each and every image.

However, why was ISO 100 recommended for bright sunny days? If you recall the f/16 sunny day rule, it recommended using an f/16 on a bright sunny day and converting the chosen film speed into a shutter speed. If ISO 100 was used, the shutter speed became 1/125th of a second. By the theory of reciprocity, f/16 and 1/125 could be changed to f/22 and 1/60th of a second. These result in better DOF and the same exposure.

For other lighting conditions, ISO 400 was recommended, because in those circumstances, you would be able to close down the aperture 2 stops from what an ISO 100 could provide. For example, on an overcast day, an f/8 was recommended with a 1/125th of a second shutter speed if using ISO 100 film. By reciprocity, this could be changed to 1/60th of a second shutter speed and f/11. When an ISO 200 is used, the f/8 would be paired with a 1/250th second shutter speed, and reciprocity would allow this to be changed to 1/60th of a second shutter speed and f/16, a 1-stop improvement. However, if ISO 400 was being used, the beginning point would be f/8 with a 1/500th of a second shutter speed, which by reciprocity could be changed to 1/60th of a second shutter speed and f/22—the same exposure with a much better DOF.

With digital imaging, you can select a different ISO film speed equivalent for each and every shot you take.

Finally, it should be mentioned that many cameras have a DOF preview button. This needs some initial explanation. Most modern lenses are designed so that when mounted onto the camera body, they are automatically set to the widest aperture the lens has. You may select a different f/stop to take a particular image, but until the shutter is depressed, the lens remains at its widest aperture. Once the shutter button is depressed, the lens shuts down to the selected f/stop. The shutter will immediately open up to its widest aperture after the image is captured. Two main reasons exist for this lens design feature. It is easier to see and compose on an image when the aperture is wide and the scene is well lit. It is also easier to focus the camera when the aperture is wide and the scene is well lit.



FIGURE 5.31
Depth of field preview button, low center, on a Nikon D90 camera.
Courtesy of Ron Taniwaki, Nikon Professional Services.

If the lens has an f/stop range from f/2 through f/22, the lens is designed to be at the f/2 aperture at the time the camera is composed and focused. Then, just as the shutter is depressed, the lens momentarily shuts down to the preselected aperture as the image is captured. Immediately, the lens will return to the f/2 aperture so the next image can be composed and focused.

The downside to this lens design is that the DOF with an f/2 is minimal, and you will see only one distance in focus, while the foreground and background will appear to be out of focus in the viewfinder.

To enable the photographer to be able to see the true DOF range, the DOF preview button, if your camera has one, allows the lens to shut down to the preselected f/stop **before** the picture is taken. The main complaint is that by having the lens shut down to an f/22 aperture, for example, so much light is cut out from the viewfinder that it is frequently too dark to see the now apparent DOF range. Many find this situation to be too frustrating to effectively use. So, many do not use the DOF preview button at all, even if their camera has one.

The DOF preview button is usually located low on the camera body to the left of the lens, if looking at the front of the camera. Fig. 5.31 shows the DOF preview button, in the lower center.

LENSES

Lens Designations

Walk into a camera store, and you will be amazed by the variety of lenses available. How do you intelligently compare one lens with another on the shelf right next to it? Each lens has characteristics you need to know. Some of the most frequent variations are discussed next.

Focal Length

The focal length of the lens is, by definition, the distance in millimeters (mm) between the optical center of a lens and the sensor when the camera is focused on infinity (∞). This aspect of the lens being focused for infinity is important because many lenses extend in length as their focus changes from infinity to their closest focusing distance.

Fig. 5.32 shows a 50 mm lens when focused on infinity (A) and the same lens when focused at its closest focusing position (B). As the lens is focused, various optical elements within the lens may change positions. When focused on infinity, the lens will be at its most compact configuration. The optical center of the lens elements would actually be farther than 50 mm when the lens is focused at any other point. It should be mentioned here that many modern lenses focus internally, without any extension of the end of the lens. The definition of focal length was formed before this modern variation of lenses. It would still be correct because the lens is always at its most compact configuration when focused on infinity.

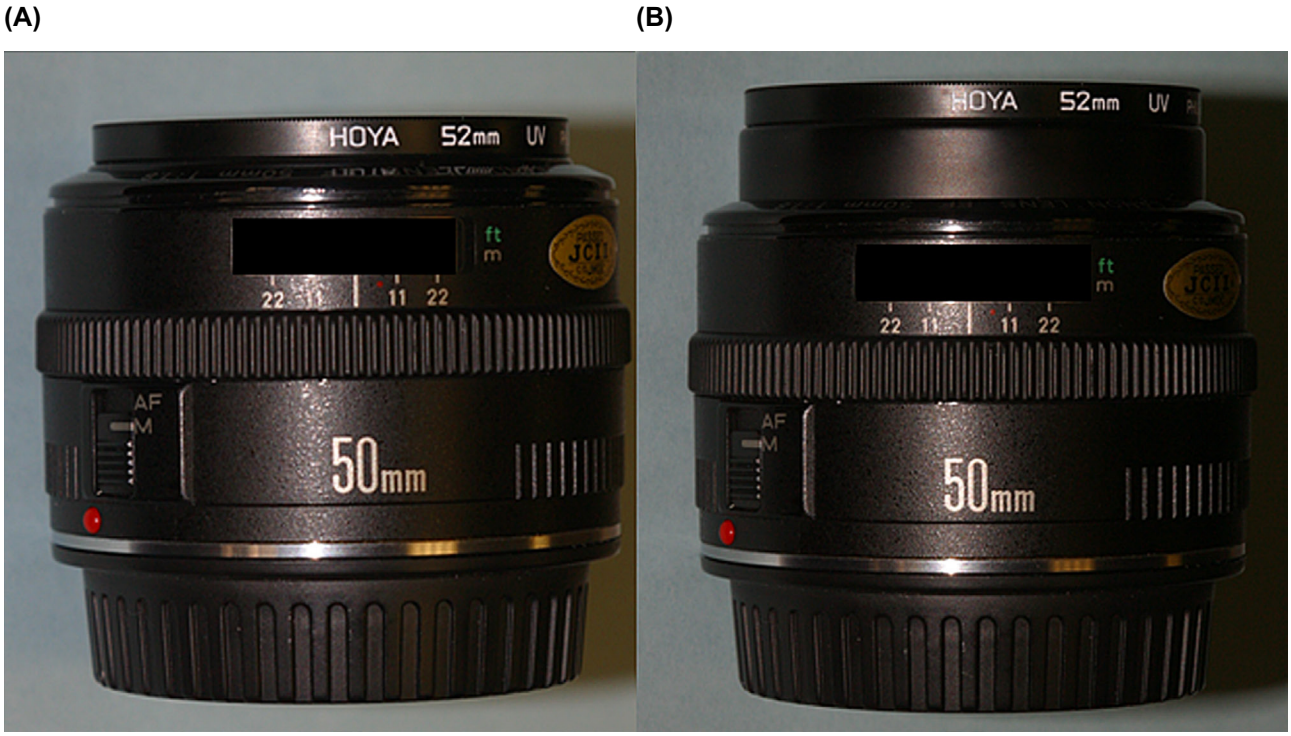


FIGURE 5.32
A 50 mm lens focused on infinity (A) At its closest focusing distance (B).

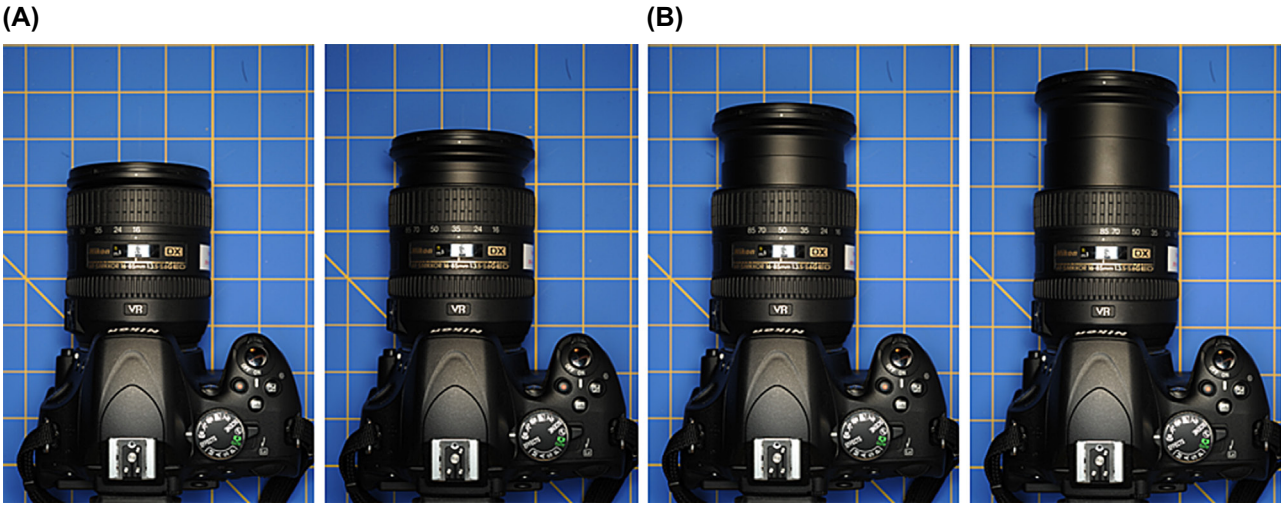


FIGURE 5.33
Zoom lens set to 16 mm (A), 35, 50, and 85 mm (B).
Courtesy of Ron Taniwaki, Nikon Professional Services.

As zoom lenses having different focal lengths are considered, it should now be obvious that their relative lengths will frequently differ with the selected focal length, which is easily demonstrated by seeing how a zoom lens changes configurations as it is set to different focal lengths. The lenses in Fig. 5.33, by the way, focus internally, so it does not matter that the focus has not been dialed to infinity. The focal lengths of these four lenses begin with 16 mm and then proceeds through 35 mm, 50 mm, and finally 85 mm. As you would expect, the length of the lens progressively gets extended more and more.



FIGURE 5.34
An 800 mm lens supported by two tripods.

Fig. 5.34 is a Nikon 400 mm lens with a 2× teleconverter, effectively making it an 800 mm lens. It is a monster. But, if you want to get up close and personal with a bad guy 400′ away from the camera, there are not many alternatives. Because of its size, it has been mounted on two tripods for additional stability.

A 50 mm lens has 50 mm in distance between the optical center of the lens and the sensor when the lens is focused on infinity. With a 100 mm lens, that distance is 100 mm between the sensor and the optical center of the lens. That is why telephoto lenses are longer than most other lenses.

"Fast" and "Slow" Lenses

When you are shopping for a lens, the dealer will sometimes refer to a lens as being "fast" or "slow." Lenses themselves do not have "speeds," but they do one aspect which affects the ultimate shutter speed that is usable for a particular photograph.

The lenses for 35 mm cameras have within them an adjustable diaphragm, which can be opened to a wide aperture or closed down to a smaller aperture to vary the amount of light that can pass through the lens toward the sensor. Adjusting this diaphragm is usually referred to as "selecting the f/stop." F/stops are one indicator of the amount of light that is allowed to reach the film.

Together, the shutter speeds and the f/stops control the total quantity of light that is allowed to ultimately reach the sensor for an exposure. The light intensity can be controlled by the amount of light coming through the lens (f/stops) and the time the light enters the camera (shutter speeds).

If a larger volume of light can be transmitted by any particular lens, a proper exposure may be obtained by using a shorter or "faster" shutter speed. If a smaller volume of light can only be transmitted by a particular lens, in the same lighting conditions, that volume will have to be transmitted for a longer time to arrive at the same exposure. It is basically a balancing act. With more light volume or larger diaphragm openings, less time or shorter shutter speeds will be needed for a proper exposure. With less volume or smaller diaphragm openings, more time or longer shutter speeds will be required for the same proper exposure.

An f/stop of f/2 is regarded as the pivotal f/stop for designating 50 mm lenses as being either "fast" or "slow." If a lens has a wider maximum lens opening than f/2, it is called a "fast" lens, because by letting in a larger volume of light, less time, or a "faster" shutter speed is needed for a proper exposure. An f/1.4 would be an example of a "fast" 50 mm lens. "Fast" lenses are more expensive because photographers value them for enabling nonflash photographs in dim light, thereby maintaining a natural look to a scene. This aspect of "fast" lenses does not have the same value to crime scene photographers because wide apertures produce the worst DOF ranges, and crime scene photographers are usually concerned with maximizing the DOF range.



FIGURE 5.35
Zoom lens set to 24 mm.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

If a 50 mm lens has a smaller lens opening than f/2 as its maximum lens opening, it is called a "slow" lens because it will require the shutter to remain open longer for the same exposure. A 50 mm lens with its widest aperture of either f/2.8 or f/3.5 would be regarded as a "slow" lens.

This issue of "fast" or "slow" lenses becomes important when you are shopping. The same focal length lens may be available with different maximum apertures. Expect to pay more for the "faster" lenses. If purchasing lenses for your agency, be comforted that "slow" lenses are perfectly suited for crime scene work, and you will save your agency some money.

Zoom lenses typically will not have the same wide apertures as 50 mm lenses. Zoom lenses will often have their widest aperture around f/3.5 or f/4. However, a zoom lens with an f/3.5 aperture as its widest aperture is said to be "faster" than another zoom lens with an f/5.6 as its widest aperture.

Lenses Are Designated by Their Widest Apertures

Because of the premium placed on the widest aperture of any particular lens, all lenses are designated by their widest aperture. It is marked on the lens barrel, and it will be marked on the packaging material. You might go shopping for a 50 mm f/1.4 lens that is regarded as very "fast" but have to settle for a more reasonably priced 50 mm f/2 lens.

Zoom lenses will be designated by their widest aperture at each extreme in their focal length. A typical zoom lens that provides for focal lengths between 35 and 105 mm may be designated as a 3.5/4.5 lens. That means the widest aperture at the 35 mm setting is f/3.5, and the widest aperture at the 105 mm setting is f/4.5.

The lens in Fig. 5.35 features focal lengths from 24 to 85 mm. As part of the name of the lens, it is designated, 1:2.8–4. This means the widest aperture at the 24 mm setting is f/2.8 and the widest aperture at the 85 mm setting is f/4.

The "Normal" Lens

Different lenses may make the scene viewed in the viewfinder appear to be different than the eye sees the scene. A 50 mm lens is considered to be the "normal" lens for a 35 mm SLR film camera because it portrays a scene in a similar way as the eye saw it. (Be aware that different camera formats will have different "normal" lenses. For instance, the "normal" lens for a medium-format camera will be an 80 mm lens. Many point-and-shoot digital cameras frequently feature a wide-angle lens as their only lens. However, most crime scene photography is done with the 35 mm SLR camera format.) A distant object viewed through a 35 mm camera with a 50 mm lens looks the same distance away as when you directly look at it. A near object, viewed through a 35 mm camera with a 50 mm lens, looks to be the same distance from you as when you look directly at it. The relative distance between the near and far objects looks the same to the eye as when viewed through a 35 mm camera with a 50 mm lens on it.

The "normal" lens for a camera system is "officially" supposed to be determined by using the diagonal of the size of the sensor; the full-frame 35 mm digital sensor is 24 × 36 mm, and Pythagorus would remind us that the hypotenuse of this right triangle would be about 43 mm. He would be correct. For some reason, 35 mm SLR film camera manufacturers have usually called the 50 mm lens the "normal" lens for this camera format. With the 50 mm lens on the camera, view the scene through the viewfinder. Immediately look up above the camera at the scene. Nothing should have changed. Close objects will look the same distance through the viewfinder as they look to the eye. Distant objects will look the same through the viewfinder as they look to the eye. The 50 mm lens is supposed to make the world appear the same when you are looking through the viewfinder as when you are looking at the world without a camera in front of your face.

However, some cameras have viewfinders with magnification ratios. Canon's current top-of-the-line EOS 5DS R, a 50.6-MP camera, has a viewfinder magnification of 0.71×, magnifying everything seen through the viewfinder. Nikon's D810A, with its 36.5-MP digital sensor, has a 0.70× frame coverage, also narrowing the view somewhat. The net result of these cameras with viewfinder magnifications is that the image you capture will be slightly larger than what you saw through the viewfinder. This should ease your mind if you tightly compose a close-up photograph of a weapon. You will not be likely to have cut off any part of the weapon when the image is printed.

The 50 mm lens, used with a digital SLR camera with a full-frame sensor, is the focal length of choice when it is a crime scene photographer's intention to offer the photograph of the crime scene in court and maintain that the photograph is "a fair and accurate representation of the scene." This deserves to be a Rule of Thumb.

RULE OF THUMB 5.6

The use of a different focal length lens may introduce lens distortion into a photograph. Wide-angle lenses will elongate the distance between the foreground and background. Telephoto lenses will compress the distance between the foreground and background. Only the 50 mm lens will capture the image without this distance distortion.

One other aspect of the 50 mm lens is that it only provides a view of the world that is about 36-degree of the field of view. Items further to the left and to the right will not be included in the field of view unless you back up. In this case, objects will appear smaller because they are now further away. If, however, it is your intent to eliminate extraneous objects from your field of view, all you need to do is move closer to the primary subject until the extraneous items are outside of the 36-degree viewpoint.

Focal Length Multipliers

With digital SLR cameras, the concept of the "normal" lens is a bit more complicated. Different digital camera manufacturers produce different sized digital sensors. Some of the digital sensors are the same size as the film negative used to be, 24 × 36 mm. However, at this time, these are normally found on only the more expensive cameras in a manufacturer's digital camera line. The medium-priced and less-expensive digital SLR cameras use digital sensors that are smaller than a film's negative was. Why does this matter? Because it has a direct effect on a lens' angle of view and, therefore, affects what is considered a "normal" focal length for a particular camera.

Nikon makes digital cameras with both sized sensors. Nikon digital cameras with the smaller digital sensor have a 1.5 **Focal Length Multiplier** on many of its medium- and low-end digital SLR cameras. Sony digital cameras also use a 1.5 focal length multiplier. Canon uses a 1.6 focal length multiplier. All these smaller digital sensors are sometimes referred to as Advanced Photo System-Classic (APS-C) sized sensors, which is a reference to the film size created in 1996, which was 25.1 × 16.7 mm. This is smaller than the 35 mm-sized sensor of 36 × 24 mm. See Fig. 5.36 for Nikon's relative sensor sizes.

How does this affect the lens' field of view? Table 5.2 may help. It shows the standard focal lengths of 20, 28, 35, 50, 70, and 100 mm compared with their digital focal length equivalents, when the digital sensor is smaller than the full-sized sensor.

The graphic in Fig. 5.37 will also help you understand this concept.

The effect is that the smaller digital sensor captures less detail than what a full-sized sensor would have. Another way to look at this is that the smaller digital sensor produces a "crop" of the image, equivalent to the effective focal lengths

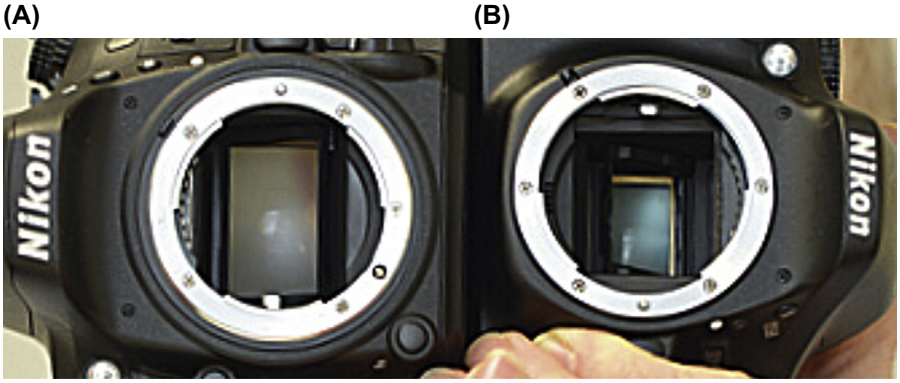


FIGURE 5.36
Full-frame sensor (A) and APS-C-sized sensor (B).

Table 5.2 Standard Film Focal Lengths Versus Digital Focal Length Equivalents

Full negative size	1.5 Focal length multiplier	1.6 Focal length multiplier
20 mm	30 mm	32 mm
28 mm	42 mm	44.8 mm
35 mm	52.5 mm	56 mm
50 mm	75 mm	80 mm
70 mm	105 mm	112 mm
100 mm	150 mm	160 mm

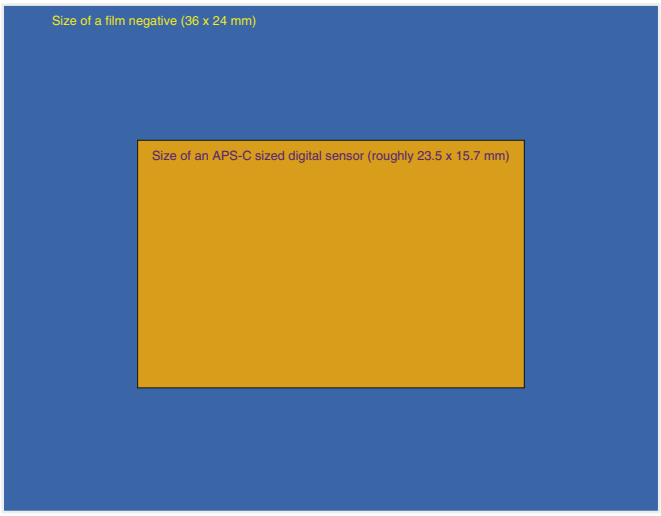


FIGURE 5.37
The relative size of a full-sized sensor and a digital APS-C-sized sensor.

in Table 5.2. For instance, if a camera with a full-sized sensor composes a certain scene with a 50 mm lens on the camera, if you are using a zoom lens, and you zoom the lens to the 75 mm setting, you see less of the scene. This is exactly what you would see when using a digital camera with a 1.5 focal length multiplier. If you are using a zoom lens, and you zoom the lens to the 80 mm setting (presuming it has one), you see less of the scene. This is exactly what you would see when using a digital camera with a 1.6 focal length multiplier. When using a digital camera with a sensor that is smaller than a full-sized digital sensor, the image that is captured resembles a "crop" of what the full-sized sensor would have captured.



FIGURE 5.38
(A) 28 mm lens and a full-frame digital sensor. (B) 35 mm lens with a full-frame digital sensor.

To take the first three images shown in Figs. 5.38 and 5.39, a digital camera with a full-frame sensor was placed on a tripod at the door to this kitchen. For the first three images, a zoom lens was set to 28 mm, then 35 mm, and finally 50 mm. Progressive "crops" of the first image are seen in the second and third images. For the fourth image, Fig. 5.39B, the camera was replaced with a digital camera that had an APS-C-sized digital sensor, with a 1.6 focal length multiplier. The same lens was used, and it was set to 50 mm. The focal length multiplier should make the 50 mm lens show the same field of view as an 80 mm lens. The fourth image shows that it does.



FIGURE 5.39
(A) 50 mm lens with a full-frame digital sensor. (B) Image taken with a 50 mm lens on a camera with a 1.6 focal length multiplier, the equivalent of an 80 mm lens.

For working crime scene photographers wishing to capture a scene as their eyes saw it, which focal length is to be used if working with an **APS-C-Sized Digital Sensor** in their camera? Return to Table 5.2 for the answer. When you are using a digital camera with either a 1.5 or 1.6 focal length multiplier, and your task is to capture an image equivalent to a 35 mm digital camera with a full-frame sensor, set your lens to about 35 mm. Actually, to be precise, if you have a sensor with a 1.5 focal length multiplier, 50/1.5 = 33.33 mm, or 33 mm. That will be your **new "normal"** focal length. If your smaller digital sensor has a 1.6 focal length multiplier, 50/1.6 = 31.25 mm, or 31 mm. That will be your **new "normal"** focal length.

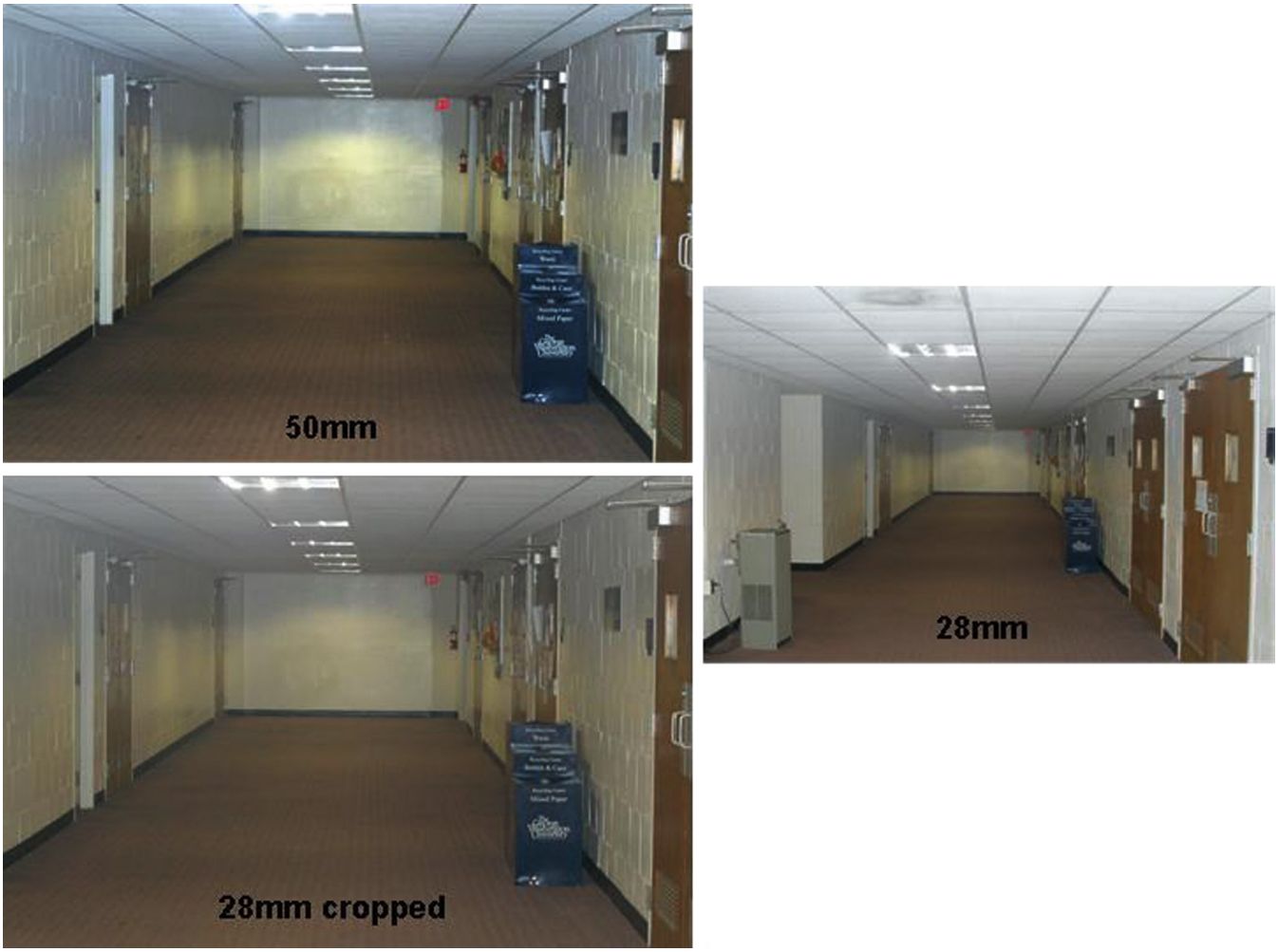


FIGURE 5.40
A crop of a wide-angle lens image eliminates the effect of elongation, which is usually a normal effect of using wide-angle lenses.

Some might think that the use of a 35 mm lens under these conditions may lead to a wide-angle lens' "elongation of the scene" effect previously pointed out. Actually, this does not happen. Since a 35 mm view of the world is being "cropped" by the smaller digital sensor, the areas in the foreground, which would show this elongation the most, are being "cropped" out, and the resultant image shows no elongation. The image examples in Fig. 5.40 help to demonstrate this effect.

Both the top-left image and the right image were taken with a digital camera with a full-sized sensor. The right image shows both a wider field of view and a pronounced elongation of the scene. The corridor did not look like this to the eye. (Ever wonder how scenes are elongated/stretched in scary movies? The cinematographer simply rotates the zoom lens from "normal" to wide-angle.) The lower-left image is a crop of the right image, done in Photoshop. Cropping the image taken with the 28 mm lens results in an image that looks "normal" and no longer elongated.

Fig. 5.41 will help make this point stronger.

The top three images of Fig. 5.41 were taken from the same location, using a digital camera with a full-frame sensor. The focal lengths of the lenses are acting "normally." The 50 mm view can be considered a "crop" of the 28 mm view. The 105 mm view can be considered a "crop" of the 50 mm view. The "crops" on the right just show magnified views. The image taken with the 50 mm lens could have also been captured with a digital camera with a 1.5 focal length multiplier, with this camera set to about 33 mm.

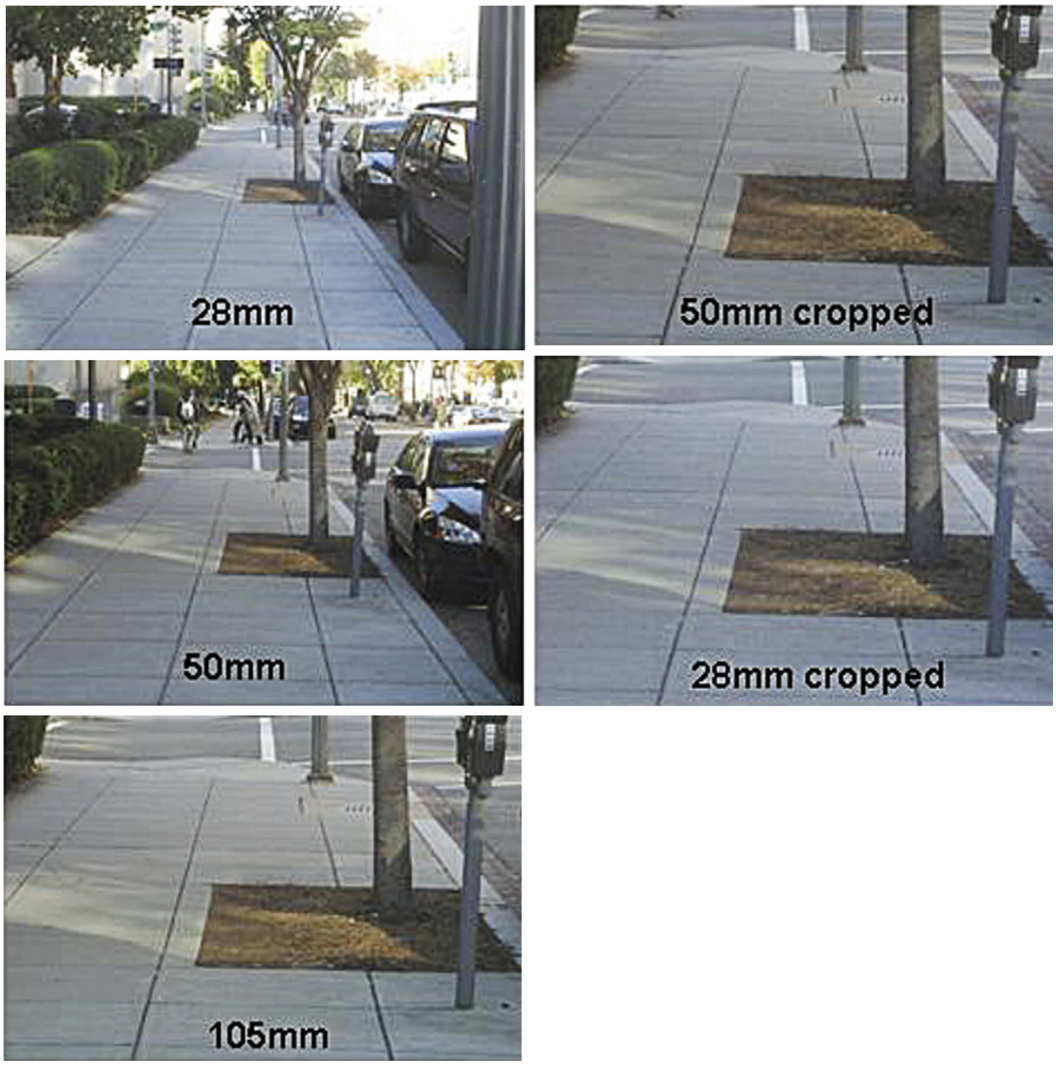


FIGURE 5.41
The same scene taken from the same position with different focal length lenses. Then, the 28 and 50 mm views were cropped.

To end this discussion of focal length multipliers, it should now be obvious that anyone wishing to take a photo with a telephoto lens is greatly helped when using a digital camera with an APS-C-sized digital sensor. A 300 mm lens will be acting like a 450 mm lens. A 500 mm lens will be acting like a 750 mm lens. The trade-off is that your wide-angle lenses are not quite so "wide" when used with these cameras. Your 20 mm lens will be acting like a 30 mm or a 32 mm lens depending on your focal length multiplier, 1.5 or 1.6, respectively.

To be perfectly accurate, telephoto lenses do magnify distant subject matter, making them larger. Digital cameras with focal length multipliers, however, only "crop" what would have been captured with a full-frame digital sensor. This "crop" is not technically true magnification. When the cropped shot is printed out at full size, and you see what had been a distant object as a larger image, sometimes you incorrectly think of this as magnification. An enlarged "crop" is not the same as magnification.

Fig. 5.42 shows various angles of view of selected lenses, used with 35 mm digital SLR cameras with full-frame sensors. Lenses range from an ultra-wide fish-eye lens that has a 180-degree view to a super-telephoto 1200 mm lens with just about a 2-degree view. Lenses with focal lengths less than 50 mm are referred to as wide-angle lenses; lenses with focal lengths more than 50 mm are referred to as telephoto lenses.

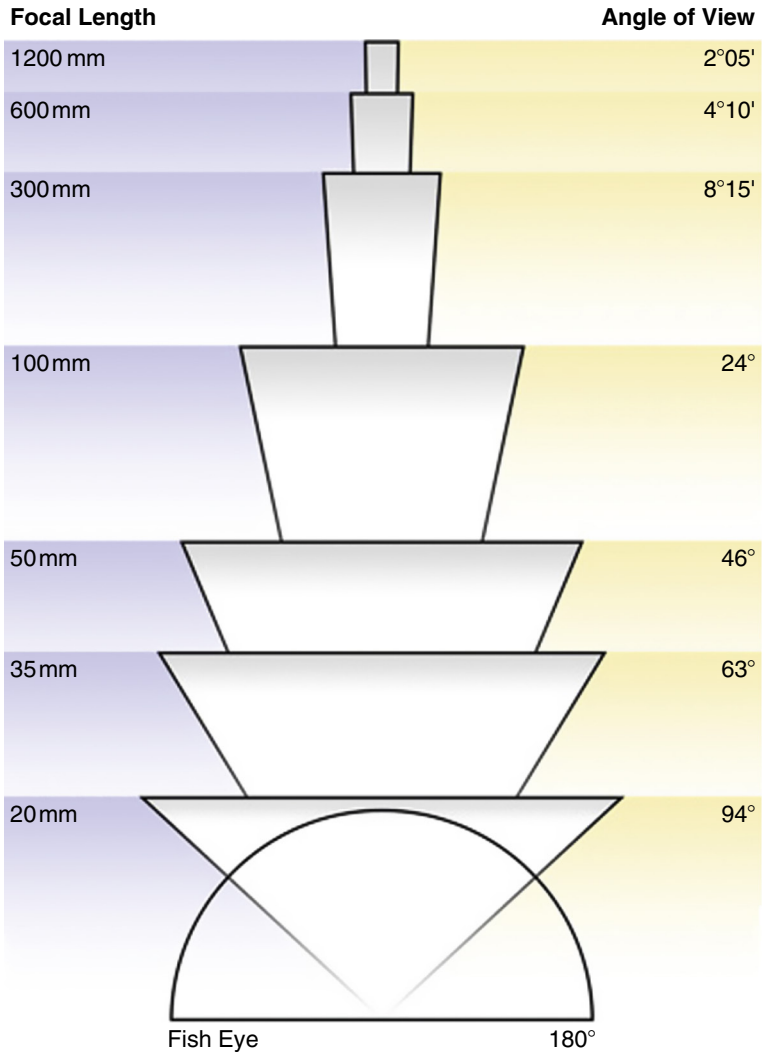


FIGURE 5.42
Various angles of view of some lenses.
Courtesy of Jeff Robinson, scamper.com.

Telephoto Lenses

Lenses with a focal length longer than 50 mm are called telephoto lenses. They can range from 60 to 1200 mm. The optical centers of these lenses are farther from the film plane than a 50 mm lens distance. This difference produces distinct changes to a photograph, compared with the 50 mm lens look. These differences are as follows:

- Magnification
- Narrower field of view
- Compression of foreground-to-background distances
- Narrower DOF range

Magnification

Telephoto lenses are perhaps best known for their ability to magnify distant objects. This telescopic effect can be determined by dividing the focal length of the telephoto lens by 50 mm. Therefore, a 100 mm lens would be the equivalent of a 2× telescope; a 300 mm lens would be the equivalent of a 6× telescope. The distant subject would be magnified by two times and six times, respectively. This magnification ability is perhaps best suited to surveillance photography, when it is necessary to identify distant subjects by photographing them while the photographer maintains a safe distance so they are not noticed.

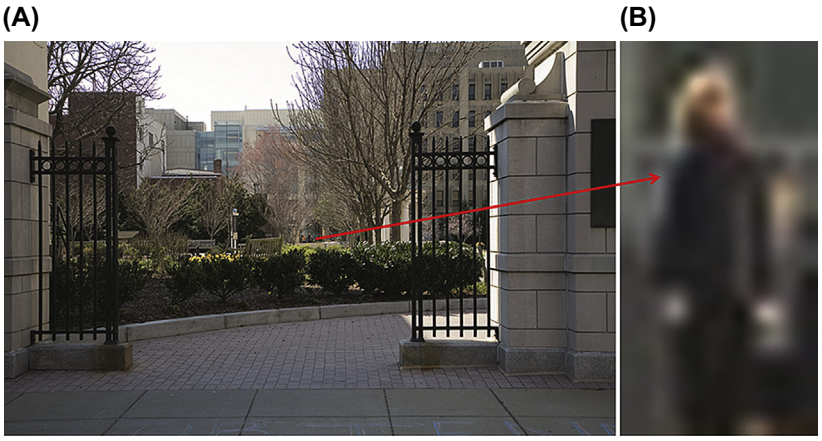


FIGURE 5.43
(A) 50 mm view, subject 400′ away. (B) 50 mm view, subject 400′ away, cropped, and enlarged.

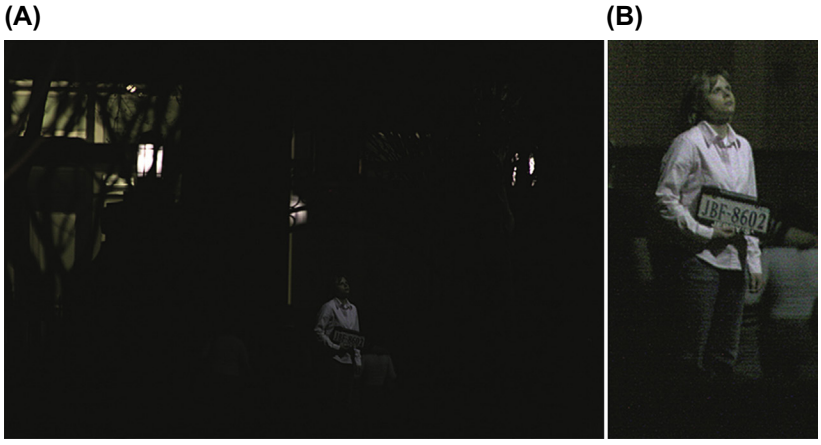


FIGURE 5.44
(A) 800 mm view, nighttime, subject 400′ away. (B) Cropped and processed.

Compare two images in Fig. 5.43: one taken with a 50 mm lens; the other, a partial crop and enlargement of the first.

In the center of Fig. 5.43A, you may be able to notice a small, vague, dark-jacketed person. It is extremely difficult to do so because the person is standing 400′ from the camera, and the image was taken with a "normal" 50 mm lens. A 50 mm lens is certainly not sufficient to resolve the detail of the subject. The Fig. 5.43B confirms this. It is a crop and enlargement of the left image, intended to show the subject "better." The resolution is not adequate to make out the subject, other than to suggest the subject may possibly be a blonde female. Individual characteristics are lacking altogether.

Fig. 5.44A is an image of the same subject standing the same distance from the camera at night. The difference here is that an 800 mm lens was used. Although the subject appears to be underexposed, she is certainly much larger. Fig. 5.44B shows the same image digitally cropped and enlarged, and the underexposure has been corrected in Photoshop. The resolution is sufficient to make out the face and to determine the letters and numbers on the license plate held by the subject. And, it appears the tag has a frame with a name on it: Jerry's. The author once owned a car from the Jerry's Ford dealership. Certainly, this focal length lens has adequate magnification for an identification of the individual. For this reason, the next Rule of Thumb has been established.

RULE OF THUMB 5.7

In surveillance situations, to be confident magnification will be adequate to recognize either a subject's face or to read a license plate, you should use a lens that has a focal length of 2 mm of lens per foot of distance between the camera and the subject.

With Fig. 5.44, an 800 mm lens was used for a distance of 400′ between the camera and subject.

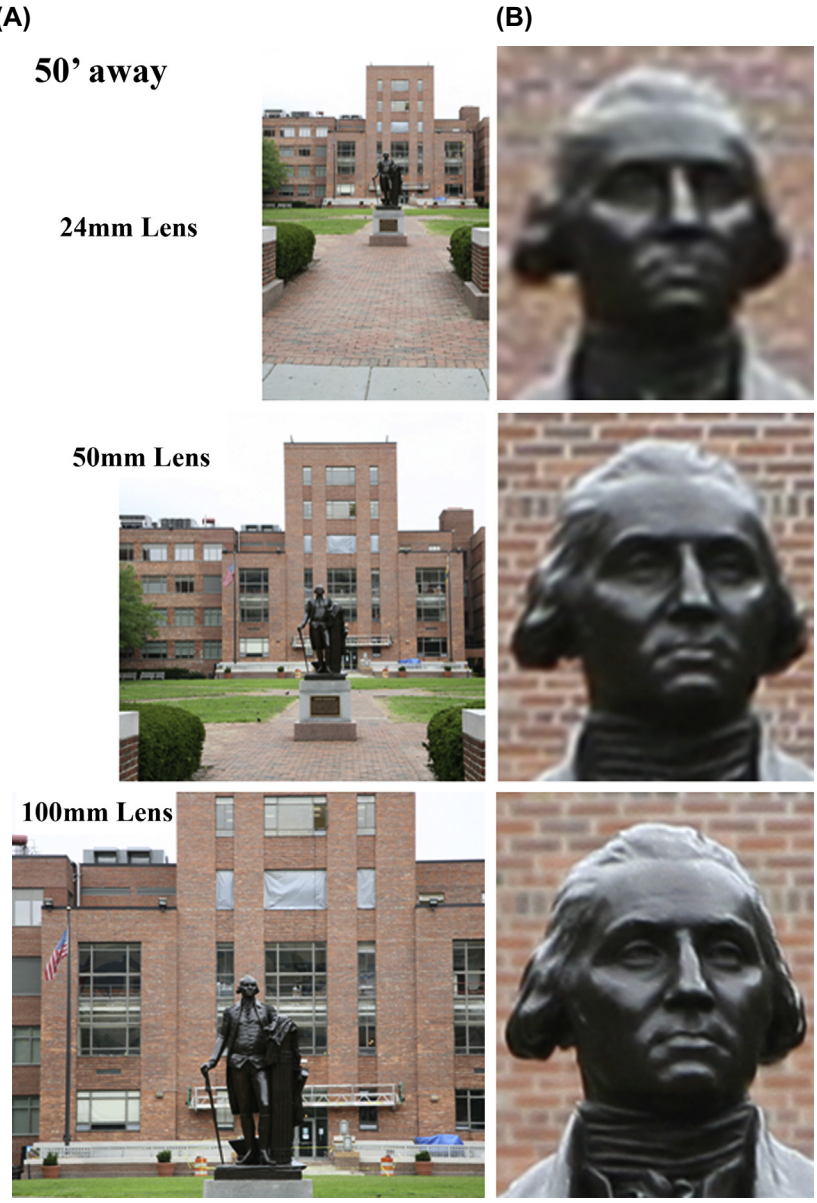


FIGURE 5.45
(A) 2, 1, and 0.5 mm of lens per foot of distance. (B) Crops.

To understand this Rule of Thumb better, examine the images shown in Fig. 5.45. On the campus of The George Washington University, you might expect to run into George several times. One of his statues is life-sized. From 50′ away, George was photographed with 24, 50, and 100 mm lenses. With the 100 mm lens, George is the size on the image that is recommended for surveillance situations. (Of course, being just 50′ away from a subject of surveillance may not be a good idea.) When his face is cropped and enlarged, you would still expect to be able to recognize it. Be aware that these images were taken with midday lighting. As the lighting gets more and more problematic, and the distances between the photographer and the subject become longer, the difficulties would increase. But, even in a nighttime situation, 2 mm of lens should be able to resolve distinguishable features. With a zoom lens adjusted to about 50 mm at a 50′ distance, 1 mm of lens per foot of distance is the result. The face is a bit smaller in the image. You would expect enlargements that had the face recognizable to be just a bit more difficult, especially in darker conditions and longer distances. With the zoom lens adjusted to about 24 mm at a 50′ distance, 0.5 mm of lens per foot of distance is the result. The face is smaller yet, compounding any attempt to resolve the face so it is recognizable. Because capturing the facial features in surveillance situations is so critical, you cannot take chances of losing the detail you seek to capture in the first place. The use of 2 mm of lens per foot of distance guarantees this detail will be obtained.

From any viewpoint of an item of evidence, if it is desired to fill the frame with critical aspects of the object, moving closer to the object matter is usually advised. However, at times moving closer is not practical. Other critical evidence may be in the way, prohibiting moving closer to the subject matter of the photograph. Or it may not be safe to step closer to the item of interest. At an arson scene, the floor may be weak just ahead of the place where the crime scene photographer is currently standing. In these situations, you should consider using a zoom lens in its telephoto setting, which will magnify the area of interest, without your having to get physically closer.

Care should be maintained that this use of a telephoto lens merely magnifies or enlarges critical details of the evidence. As explained previously, use of a telephoto lens can distort the relative perspective between objects. Therefore, a zoom lens cannot be used to show "a fair and accurate representation of the scene," specifically the distance between two or more objects, if a linear point of view has been established. The use of a zoom lens to enlarge an individual element of the scene is, however, permissible.

An example is helpful. At a remote fire scene with fatalities, an electric clock on a wall suggested the time of the fire when the fire damaged the electric cord and stopped the clock. The floor in front of the clock had completely collapsed. The clock could be viewed only from another room that had a wall also burned away. To photograph the clock, the crime scene photographer used a telephoto lens. The clock was magnified and filled the frame of the viewfinder. The telephoto lens was used for its strength: magnification. No other scene details were included in the composition to avoid the tendency of telephoto lenses to compress foreground-to-background distances.

Narrower Field of View

As you can see in the preceding photographs, telephoto lenses also take in a narrower field of view than the 50 mm lens. Although the 50 mm lens takes in 36–46 degrees of the scene, a 100 mm lens takes in only 24-degree, a 300 mm lens takes in only about 8-degree, a 600 mm lens takes in only about 4-degree, and a 1200 mm lens takes in only about a 2-degree view of the scene. This narrower field of view can be useful; by eliminating extraneous items to the left and to the right, the photographer can force the viewer to concentrate on the intended primary subject, rather than being distracted by a myriad of objects in the field of view.

Compression of the Foreground and Background

Because the background will be magnified with a telephoto lens, making it appear enlarged, the relative perceived distance between the camera and the background is necessarily compressed. Objects appear closer together than they really were. This perceived distance between the foreground (the photographer's position) and a magnified object in the background appears to be shorter.

Consider how this might affect skid marks at a fatal accident scene. If the photographer frames the scene from the beginning of 100′ of skid marks leading to the place where the vehicles are found resting together and uses a 50 mm lens, or its equivalent, to capture the image, the resulting photograph will duplicate the scene as the eye had seen it. If a 100 mm lens is used instead, the vehicles in the background will appear to be closer to the photographer than they had been in reality, and the perceived length of the skid marks will appear to be shorter than they originally were, which distorts reality. The photograph taken with a telephoto lens should not be used in court as "a fair and accurate representation of the scene as it appeared." An unscrupulous defense attorney, representing the driver who skidded, may be tempted to hire a photographer to take photos of the skid marks using a telephoto lens. The resulting shorter skid marks can be interpreted by the jury as suggestive of less speed just before the accident.

The images in Fig. 5.46 demonstrate this idea, although they are images of double yellow lines instead of skid marks. Fig. 5.46A shows the length of the double yellow lines when photographed with a 50 mm lens, which is also the length of the lines as seen by the eye. Fig. 5.46B shows the same double yellow lines photographed with a 100 mm lens. This lens compacts the apparent true length of the lines, making them appear shorter. Crime scene photographers need to understand that using telephoto lenses with vertically viewed evidence will alter their "fair and accurate" appearance so that they are not tempted to use these lenses in these situations. They also need to be aware of the effect of compacting foreground-to-background distances in case photographs presented by the defense look radically different from their own, so they can explain the differences to the judge and jury in court.

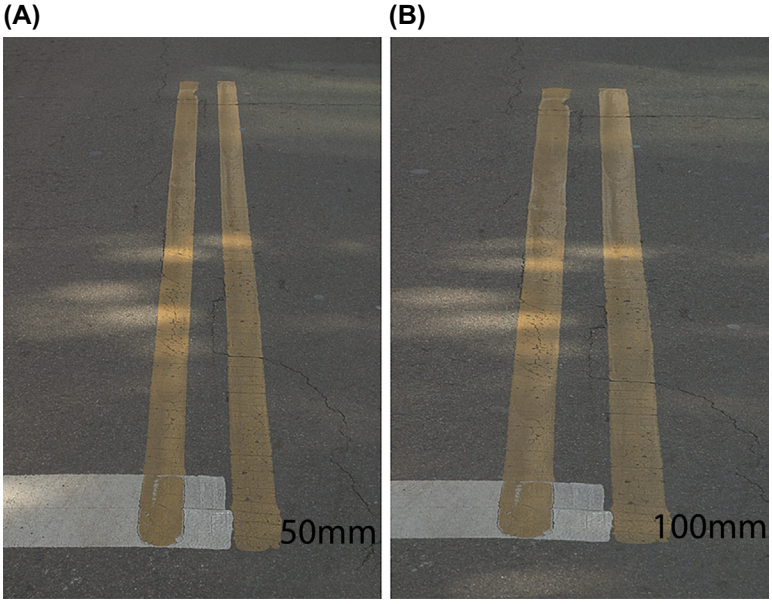


FIGURE 5.46
(A) 50 mm lens with double yellow lines. (B) Same double yellow lines with 100 mm lens.

Because of this compression effect, telephoto lenses are used in law enforcement mostly for their magnification qualities: to make it easier to recognize distant objects. The use of telephoto lenses to document overall crime scenes and overall accident scenes is strongly discouraged because of the relative distance distortion they create.

Narrower Depth of Field

As mentioned earlier, DOF is the variable area, from foreground to background, of what appears to be in sharp focus. Another effect of using a telephoto lens is a reduction in the DOF area. When using a telephoto lens, less appears to be in focus than when using a 50 mm lens. Why is this?

The same f/stop will produce different diameters of the diaphragm with different focal length lenses. Recall Fig. 5.28.

Should you use an f/8 with a 24 mm lens, a 50 mm lens, and a 100 mm lens, the resulting aperture size will be different with each lens. With a telephoto lens, the diameter of the diaphragm will be the largest compared with either a normal lens or a wide-angle lens. The telephoto lens would, therefore, have its circles of confusion, which are still perceived to be in focus to the eye, closer to the plane of exact focus, which is the sensor. The result is a shorter DOF range.

When used in surveillance situations, this reduced DOF range is usually not a problem because you will be focusing on relatively small areas or on individuals. Even the widest apertures used with telephoto lenses will produce some DOF when distant scenes or subjects are focused on.

Wide-Angle Lenses

Lenses with a shorter focal length than 50 mm are called wide-angle lenses. Wide-angle lenses can range from a 35 mm lens to a true fish-eye lens, which can capture 180 degrees of detail. The optical centers of these lenses are significantly closer to the film plane than a 50 mm lens' distance. This difference produces distinct changes to a photograph compared with the 50 mm lens look. These differences are:

- Wider field of view
- Elongation of foreground-to-background distances
- Increased DOF

Wider Field of View

Wide-angle lenses naturally capture wider views of the scene. The relative increase in the field of view can be very close to what a normal 50 mm lens would capture when using a zoom lens set to about 40 or 45 mm. Remember that the true diagonal of a full-sized digital sensor that is 24 mm high and 36 mm long is 43 mm. Therefore, when the scene is viewed from a zoom lens set at about 43 mm, the scene should look exactly the same as when you remove your eye from the viewfinder. If not, some magnification ratio may be set into the viewfinder optics. Check your camera's manual.

A 35 mm lens, and wider lenses, should begin to show more and more of the scene in the viewfinder, which becomes extremely handy when you have the duty to photograph wide objects, like the exterior façade of a large building. With just a 50 mm lens, you would have to take many more photographs. With a wide-angle lens, you would be able to capture the same overall detail with fewer images. The same would apply when faced with the need to capture interior overall photographs of a room that contains a crime scene. If you want to capture the full 360-degree view of all the walls, using a wide-angle lens would reduce the number of photos required.

Fig. 5.47A shows the view of a kitchen while using a 50 mm lens, which is the typical view that a 50 mm lens offers. Fig. 5.47B was taken from the same position, but with a 28 mm lens. Much more of the scene has been captured from left to right. With moderate wide-angle lenses, such as 35 and 28 mm lenses, one perceived difference in photographs is this wider field of view. The other effect is that the rear of the scene appears to be further from the photographer than it really was, suggesting the room may be larger than it really is. As much wider focal lengths are used, usually at around 20 mm and wider, another effect can also be noticed. Vertical lines at the left and right edges of the image begin to bow outward more and more.

(A)



(B)



FIGURE 5.47
(A) Kitchen area as viewed through a 50 mm lens. (B) Kitchen area as viewed through a 28 mm lens.
Courtesy of Dale Rio, GWU MS student.

Notice how all the edges of Fig. 5.48A appear to be bowed outward. This image was captured with a 24 mm lens. The bowing outward of vertical lines at the edges of an image is referred to as barrel distortion, and many photographers use it for its creative effects. Crime scene photographers, however, usually try to avoid this effect. Fig. 5.48B was taken with a normal lens, and the barrel distortion has been eliminated.

Avoiding the widest of the wide-angle lens choices can accomplish this task. Again, the 35 and 28 mm lenses are used most by crime scene photographers because a distinct gain exists in the left-to-right field of view, without incurring the barrel distortion wider-angle focal lengths can sometimes produce.

At times, the barrel distortion is replaced by having the tops of vertical elements at the edges of the image appear to be leaning inward, as in Fig. 5.49. Who has not seen a photo from a wedding where the entire wedding party is standing shoulder-to-shoulder and photographed with a wide-angle lens? Notice how the people at the left and right sides seem to be leaning in toward the center of the image? The culprit: a wide-angle lens.

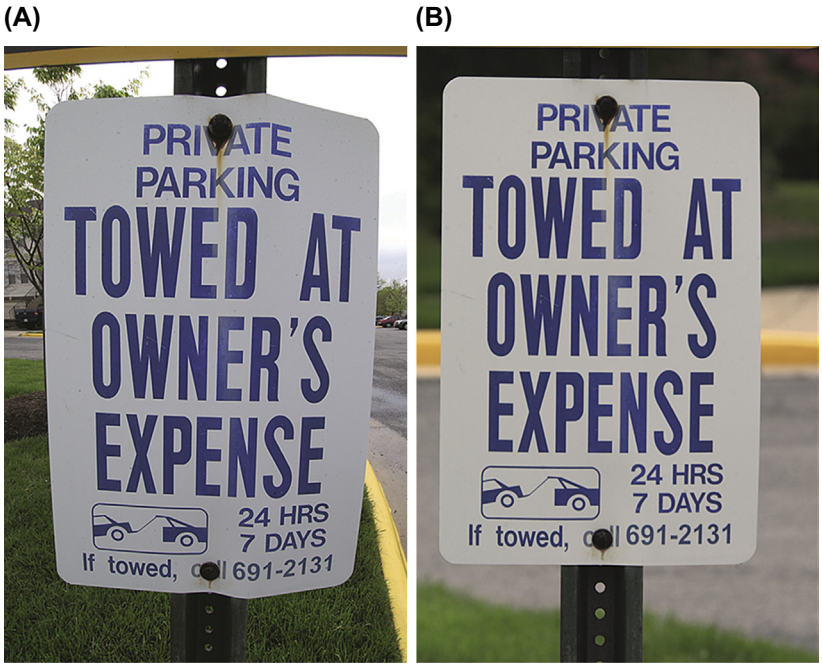


FIGURE 5.48
(A) A wide-angle lens producing barrel distortion. (B) A short telephoto lens eliminates the barrel distortion.
Courtesy of Sarah Reeve, GWU MFS student.



FIGURE 5.49
Building edges tilting in with wide-angle lens.

Elongation of Foreground and Background

A wide-angle lens seems to make the background appear further away than it really was. Going back to the example of an accident with skid marks, if the wrecked cars are now appearing to be further away, the skid marks running from the camera's position to the vehicles appear to be longer than they really were. A juror may interpret longer skid marks as an indication of greater speed. Again, when "a fair and accurate representation of the scene" is the desired goal of the photographer, wide-angle lenses should not be used.

The images of Fig. 5.50 are the same double lines previously considered in the section on telephoto lens effects. Fig. 5.50B, however, shows the same double yellow lines captured with a 28 mm lens. The lines appear to be stretched longer than they appeared to the eye when the photograph was taken, which is certainly not an accurate representation of the scene as it appeared to personnel at the scene. Fig. 5.50A could be used in court; Fig. 5.50B should not be used in court.

As with telephoto lenses, you can use a wide-angle lens for its strength, without incurring its weakness. With telephoto lenses, their strength is magnification. Their weakness is perspective distortion in the form of foreground-to-background compression. The strength of a wide-angle lens is its ability to capture more detail to the left and to the right. The weakness of the wide-angle lens is perspective distortion in the form of foreground-to-background elongation. How can you use its strength without also having the image suffer from its weakness? If you are careful with your composition, by carefully eliminating much foreground-to-background detail in the field of view, you can use a wide-angle lens for its ability to capture more details to the left and right.

Fig. 5.51 shows two foreground-to-background distance variations with different focal length lenses. Fig. 5.51A was taken with a 35 mm lens; the Fig. 5.51B was taken with a 50 mm lens. Both were photographed from the same location. Because the wide-angle lens shows the buildings apparently further away from the photographer, a viewer of only one of the images may incorrectly assume the distance between photographer and the buildings was greater than it is in reality, which is the distance distortion to be avoided with wide-angle lenses. However, the 50 mm lens may not show as wide a scene as desired. Can you have wide views without foreground-to-background distortion? Yes. See Fig. 5.52.

To retain the strength of the wide-angle lens, its ability to capture wider views, without its negative effect, its tendency to elongate the scene causing a misperception of the foreground's depth, the building is composed to eliminate the foreground. Just raise the camera up until the bottom edge of the viewfinder includes the bottom of the structure you want to photograph. Better to have a bit more sky in the composition than distorted foreground.

Increased Depth of Field

Another effect of using a wide-angle lens is an increase in the DOF. There will appear to be more in focus between the foreground and the background than when using a 50 mm lens. This is again a result of the equation FLL/f/stop = DOD.

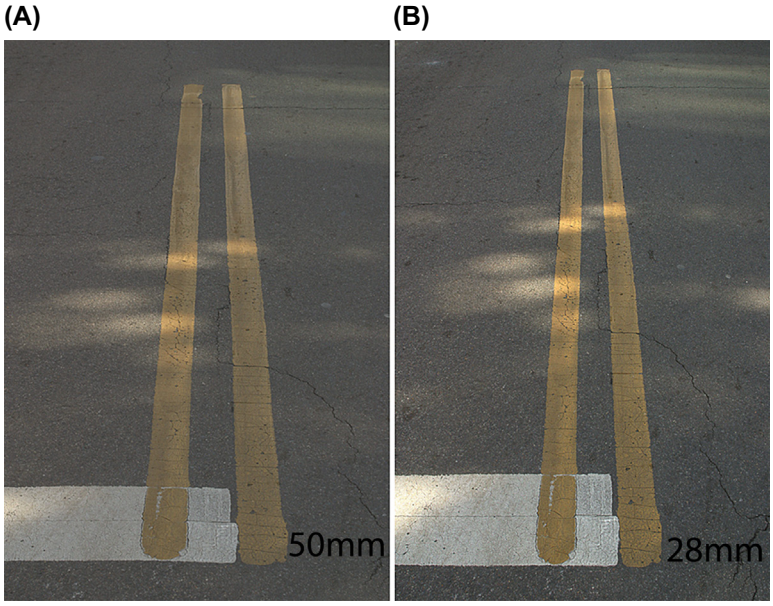


FIGURE 5.50
(A) 50 mm lens with double yellow lines. (B) Same double yellow lines with 28 mm lens.

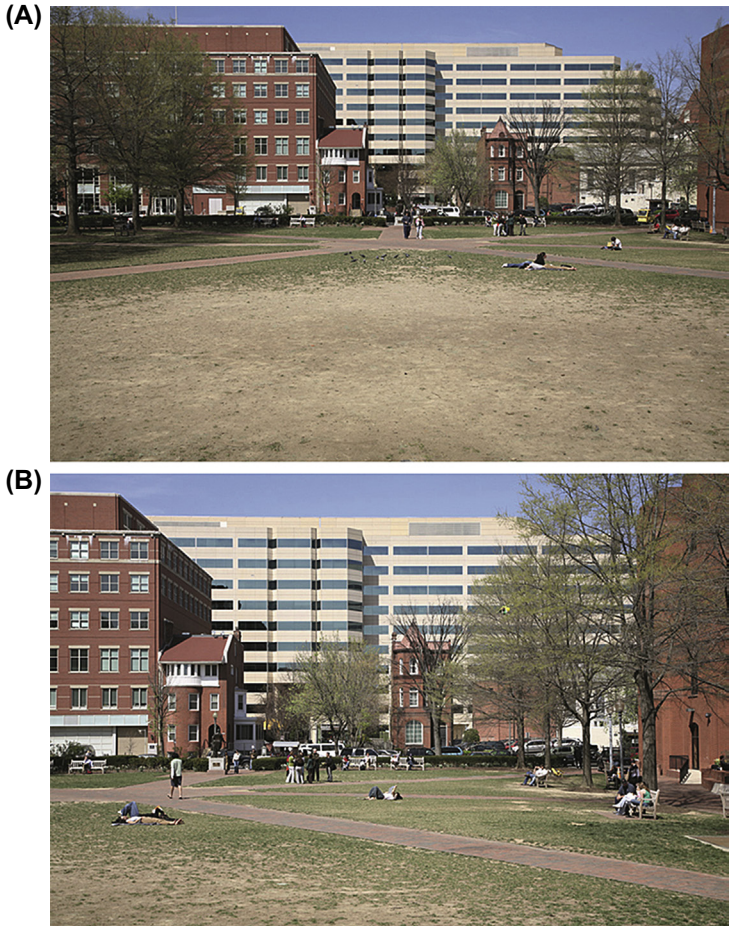


FIGURE 5.51
(A) Buildings and foreground, 35 mm lens. (B) Buildings and foreground, 50 mm lens.



FIGURE 5.52
Building without foreground, 35 mm lens.

The same f/stop used with different lenses will produce different diameters of the diaphragms: 100 mm/f/8 results in a DOD of 12.5 mm; 50 mm/f/8 = 6.25 mm; and 24 mm/f/8 = 3 mm. Light coming through a smaller aperture will result in the circles of confusion, perceived by the eye to be in focus, to be farther from the plane of exact focus at the sensor. Recall Fig. 5.50.

Unfortunately, this increased DOF is rarely usable by crime scene photographers because at the same time a wide-angle lens is causing the perspective distortion previously mentioned. Despite the Cardinal Rule to maximize DOF, you cannot use wide-angle lenses for most of your photography.

Macro Lenses

Telephoto lenses provide magnification of distant objects, but if the need is to magnify small objects to fill the frame of a photograph, other types of magnification are needed. To put this into perspective, consider that the normal 50 mm lens, when it is focused at its minimum focusing distance, will fill the frame of the viewfinder with an object that is approximately 6″ × 9″.

Many 50 mm lenses have about 18″ as their closest focusing distance. If you position the camera closer than 18″ to the object being photographed, the lens will not focus. Therefore, anything smaller than 6″ × 9″ will require additional enlarging to truly fill the frame.

Magnification With a 1:1 Ratio

Another way this situation is usually explained is by saying that a typical 50 mm lens has only a 1:7 magnification ratio. This means that an object the size of a full-sized digital sensor, photographed with a 50 mm lens at its minimum focusing distance, will be 1/7th of its real size in the viewfinder or when that image is made into a print without enlargement. Or, seven objects the size of a fingerprint will fill the frame when photographed with a 50 mm lens focused to its closest focusing distance. Fig. 5.53 will help clarify this point.

Fig. 5.53 shows that about seven fingerprints, stacked vertically, fill the frame with a 50 mm lens. When equipment providing a 1:1 magnification ratio is used, a single fingerprint fills the frame nicely, as in Fig. 5.54.

These concepts about magnification ratios are made more confusing because lens manufacturers will advertise that a lens has macro capabilities and charge a premium price for it, but when the literature is closely examined, the lens turns out to have only a 1:5 or 1:4 magnification ratio, which is only a slight improvement from what a 50-mm lens provides without any help.

For crime scene work, the macro capability desired is a 1:1 magnification ratio, but a 1:2 ratio is acceptable. Anything less will have small objects appearing small on full-sized prints or will require the darkroom operator to spend a lot of time enlarging small items of evidence. The smaller the evidence is on the negative, the more it will have to be enlarged to have the item appear to fill the frame of a print made from that negative.

Forensic laboratory experts will want a life-sized image to work with to compare to evidence recovered from a suspect. The more the image has to be enlarged to accomplish this, the more loss of detail possible from the enlargement process. Therefore, it should be a crime scene photographer's constant goal to ensure the evidence appears as large as it can be on the negative when the image is originally captured.

How can these magnification ratios be obtained?

Macro Options

Three common alternatives exist to achieve a 1:1 magnification ratio:

- Use a true macro lens.
- Use an **Extension Tube**.
- Use close-up filters.

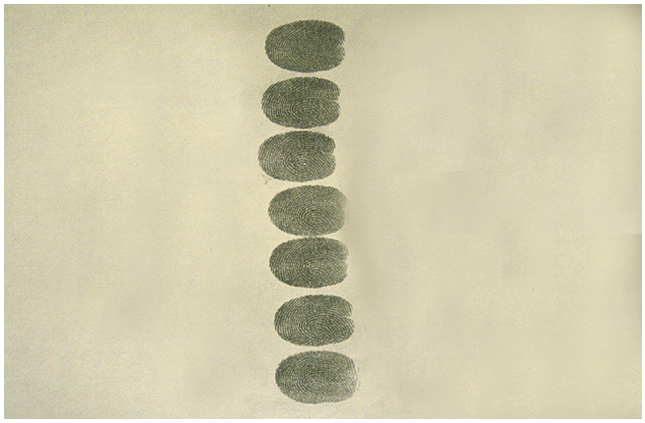


FIGURE 5.53
1:7 magnification ratio of a 50 mm lens.

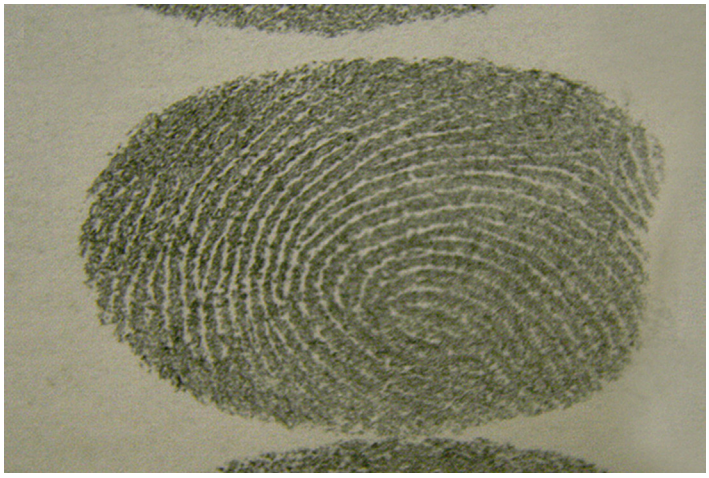


FIGURE 5.54
1:1 magnification ratio of a fingerprint.



FIGURE 5.55
Camera with a macro lens.

MACRO LENSES

Macro lenses providing a 1:1 or 1:2 magnification ratio can be very expensive. Macro lenses made by Nikon and Canon can cost between $300 and $700.

Macro lenses, however, produce the clearest, crispest close-ups of the three options discussed in this text. They should be your first choice if you have any influence in the purchasing decisions of your agency.

Fig. 5.55 is an example of a macro lens affixed to a camera. The images in Fig. 5.56 show just the lens and the window where specific magnification ratios can be selected. On the left side of the window there appears an orange "1:" designation, and inside the window you can see that the focus point, the gold line above the "R" of "Nikkor," is aligned with the orange "1." This represents the classic magnification ration of 1:1, and it will produce an image of a single fingerprint nicely filling the frame, like in Fig. 5.54. This particular macro lens gives the photographer the option of preselecting magnification ratios from between 1:1 to 1:10. With three fingerprints adjacent to each other, the magnification ration of 1:3 would produce an image like Fig. 5.57.



FIGURE 5.56
Macro lens set to 1:1 magnification ratio.



FIGURE 5.57
Three fingerprints with macro lens set to 1:3 magnification ratio.

EXTENSION TUBES

Second on your shopping list of equipment providing 1:1 magnification ratios should be an extension tube. An extension tube is a supplemental lens, inserted between the primary lens and the camera body, to move the optical center of the primary lens farther from the sensor's plane. This results in magnification. See Fig. 5.58. Some manufacturers provide differing lengths of extension tubes to choose from, providing differing magnifications. Extension tubes can cost approximately $75 to $100. The various extension tubes can also be stacked, providing more magnification when used together. Some manufacturers make extension tubes that are completely without any lens elements. You can stick your finger through the center of the tube. Some manufacturers incorporate lens elements into the tube to assist with the magnification process.

Another way to vary the magnification possibilities is to use the extension tube with a zoom lens rather than a prime lens with just one focal length. By altering the focal length, you can control the amount of magnification desired. Fig. 5.59 shows the alignment of camera body, extension tube, and a zoom lens. Fig. 5.60 shows the magnification of the extension tube used with the zoom lens set at 105 mm.

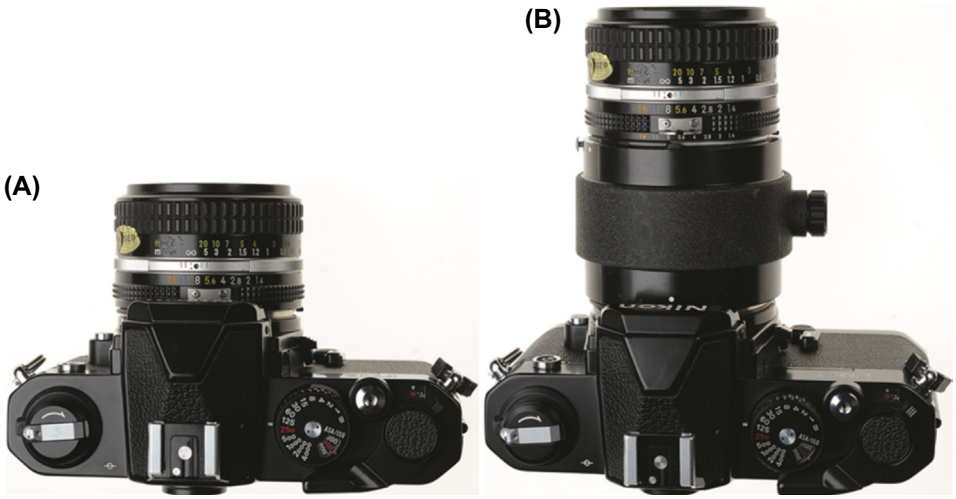


FIGURE 5.58
(A) Camera and lens. (B) Extension tube added between the camera and lens.



FIGURE 5.59
Lens, extension tube, and camera body.

CLOSE-UP FILTERS/DIOPTERS/SUBLENSES

A more cost-effective choice, if the budget is limited, which provides magnification ranges from 1:6 to 1:2, is the supplemental **Close-Up Filter Set.** This set of three filters with differing magnifications can be stacked for different magnification ratios (Fig. 5.61).

The individual filters are usually designated a +1, +2, and +4. The +1 and +2 can be stacked for the equivalent of a +3. The +4 and +2 can be stacked for the equivalent of a +6. When more than one filter is used, it is recommended to screw the highest number onto the primary lens and apply the weaker filter last. Some manufacturers suggest that all three filters should not be used together. Their reasoning is that each addition of glass between the evidence and the digital sensor can potentially degrade the quality of the resulting image.

Another consideration is that many agencies recognize the wisdom of purchasing the best lenses that are currently affordable. After all, the quality of the final image depends greatly on the quality of the lens that captured the image in the first place. But, sometimes, when the decision to purchase close-up filters is made, that same reasoning gets lost. To be consistent and logical, if it makes sense to purchase good-quality lenses, it is just as important to purchase good quality close-up filters. Putting inferior glass on the end of an expensive high-quality lens serves only to degrade the primary lens and its resultant image.



FIGURE 5.60
Magnification with the extension tube and a 105 mm lens.



FIGURE 5.61
Close-up filter set.

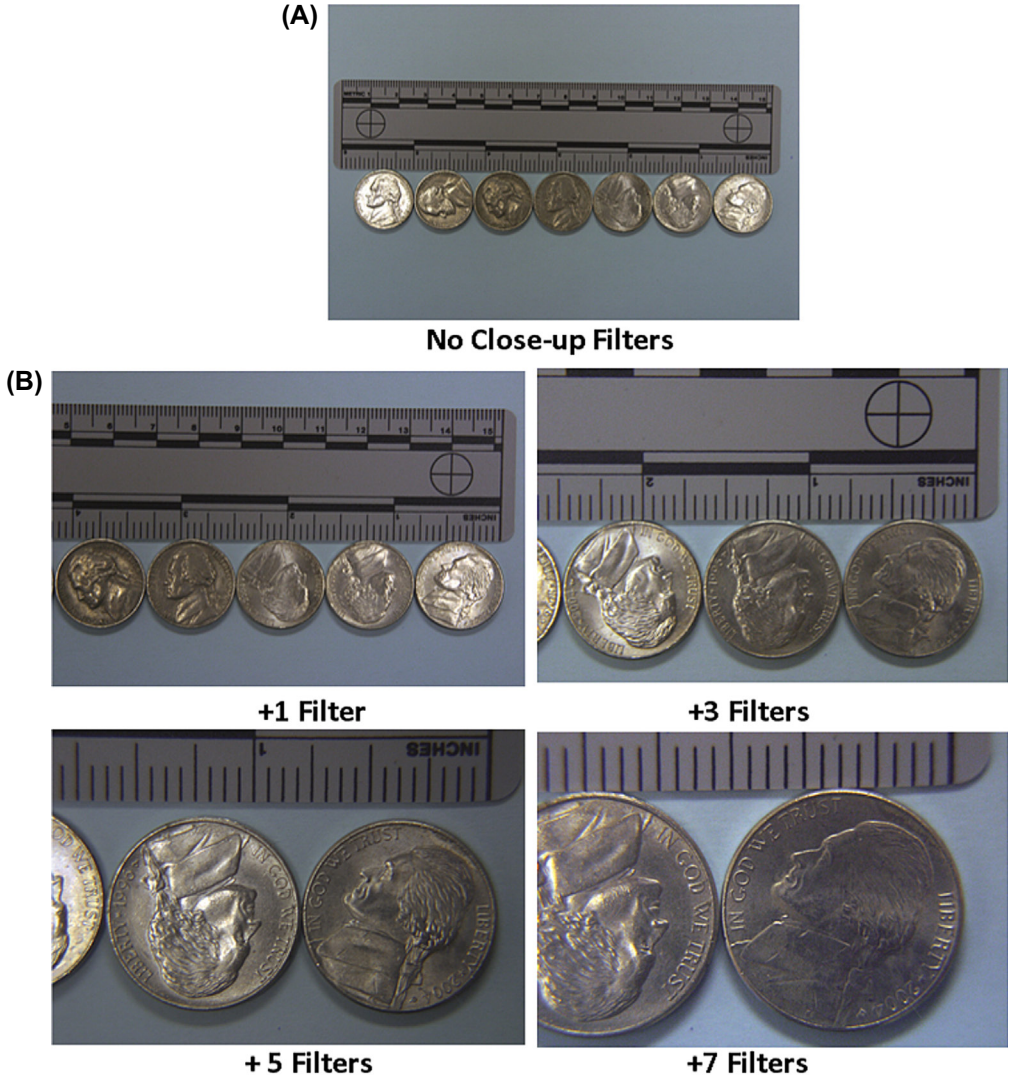


FIGURE 5.62
(A) No close-up filters. Then, (B) a +1, +3, +5, and +7 filters.

Close-up filter sets cost approximately $30 to $50, depending on manufacturer. Being able to stack the lenses in different combinations, changing the magnification ratio to match the size of the object, makes them quite versatile. The sequence of images in Fig. 5.62 shows a 50 mm lens used without any close-up filters, then a +1, +3, +5, and +7 used with a series of nickels placed side by side to show the progressive magnification possibilities as differing combinations of close-up filters are used together.

LENSES WITH VIBRATION REDUCTION OR IMAGE STABILIZATION

Many newer lenses feature what is referred to as either **Vibration Reduction (VR)** or **Image Stabilization (IS)**. Some cameras will also advertise their camera's digital sensor has "antishake" technology. To achieve this effect, either the lens elements or the digital sensor itself can gyroscopically move as the camera detects movement, counteracting the camera "shake." This capability usually becomes a benefit in one of three situations.

- You may want to hand-hold a telephoto lens, or a zoom lens with a telephoto option, rather than put the camera on a tripod. Telephoto lenses usually require faster shutter speeds to avoid blurred images. The normal recommendation when hand-holding a telephoto lens is to use a shutter speed that is the reciprocal of the focal length of the lens. That would mean hand-holding a camera with a 500 mm lens would require using a shutter speed of 1/500th of a second. That shutter speed, however, is problematic in dim lighting conditions because it severely restricts the light entering the camera. Normally, putting the camera with a telephoto lens on a tripod allows the use of slower shutter speeds, making proper exposures in dim lighting with telephoto lenses easier.

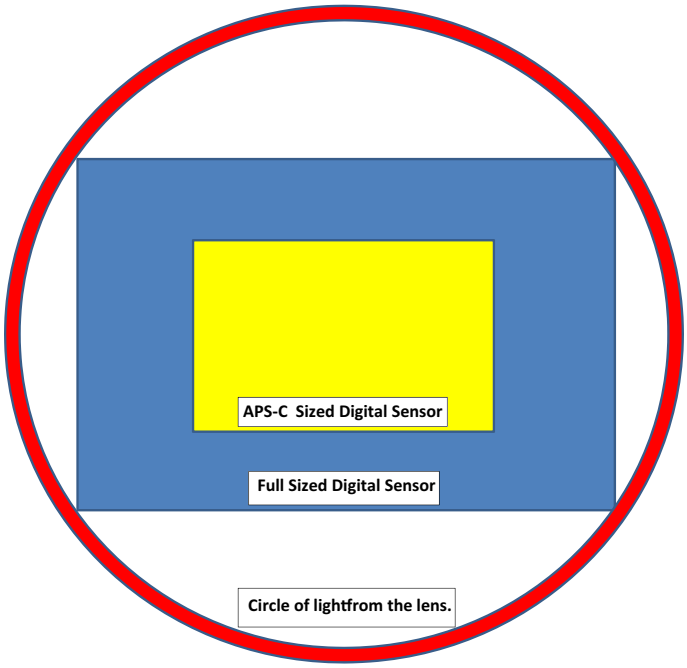


FIGURE 5.63
The *blue* rectangle is the size of a film negative. The smaller *yellow* rectangle is the size of an APS-C digital sensor. The *circle* represents the light coming through a regular lens into the camera body.

- When it is cold outside, and the photographer feels shivering may produce blurred images because of the additional camera motion, VR can help avoid the need to go to a faster shutter speed, like 1/125 or 1/250.
- You may also want to use a camera with a slower shutter speed. The slower shutter speed may be needed for a proper exposure, as when you are trying to shoot moving subjects in dim lighting or, for creative reasons, when you may want some sense of blur in the image.

In any case, VR and IS systems can usually guarantee the absence of blur when using shutter speeds up to 2 stops slower than "normal." Manufacturers may also claim the elimination or reduction of blur at 3 to 4 stops slower than a prudent person would use. For static crime scenes, this is usually not an issue. For fast-moving surveillance situations, this capability is particularly well suited.

DIGITAL LENSES SPECIFICALLY DESIGNED FOR DIGITAL CAMERAS

When digital SLR cameras first became popular, their sensors were smaller than a film camera's negative. This is the APS-C digital sensor, previously mentioned. See Fig. 5.63 . When lenses, designed to be used on a film camera, were used with these new digital cameras, the focal length multiplier effect was noticed. Because the APS-C digital sensor was smaller than the film negative, the light coming into the camera through a lens created a circle over the APS-C digital sensor much larger than the digital sensor. The digital sensor could record only a portion of the data—hence, the focal length multiplier effect.

Some camera manufacturers decided they could make new lenses specifically for their digital cameras with APS-C-sized sensors. These new lenses would create a circle of light within the camera body that "fit" the smaller digital sensor. Nikon and other manufacturers called these lenses "DX digital lenses"; Canon called the new lenses "EF-S lenses." These new lenses were smaller, lighter (less glass was needed), sometimes faster (featuring a wider aperture), and less expensive.

The downside to these lenses was that they could not be used with film cameras or digital cameras offering a full-sized digital sensor. This was fine when many digital camera manufacturers did not even make digital cameras with full-sized sensors. And, the cameras that did have full-sized sensors were featured only on the manufacturers' top-of-the-line expensive digital cameras. However, these full-frame sensors in digital cameras have become very popular, and this feature has migrated to some midline cameras. If this trend continues, and full-framed sensors become the new standard, those with a great collection of DX/EF-S lenses will find themselves having to buy new lenses. Caveat Emptor![1]

[1]Let the buyer beware!

Reading the future can be very tricky, but regular lenses, designed for film cameras and digital cameras with full-sized sensors, will probably continue to work on both types of digital cameras.

Lens Optical Problems

In the late 1970s, when this author was first taught crime scene photography techniques, the instructor stated that whenever critical comparisons, now called examination quality photographs, were to be taken, the following Rule of Thumb was to be used.

RULE OF THUMB 5.8

Never use the two smallest or the two largest apertures of the lens' f/stop continuum when critical comparison (examination quality) photographs are taken.

The preceding Rule of Thumb was certainly an interesting admonition, so it was fair to ask, "Why not?" The answer received was unsatisfying. He said he was not sure exactly why, but that it was what he was taught when he first learned crime scene photography, so he was passing on the best information he could.

Researching optics and camera lens design suggests the answer. The optics used in camera lenses have the same optical problems suffered by microscopes and telescopes. Despite camera lens manufacturers' advertising claims, these lens problems can only be minimized through modern lens design and materials; they cannot be totally eliminated. Unfortunately, this information is not readily available from the current crop of resources (books, journals, magazine articles, etc.) dedicated to issues related to crime scene photography.

Where are microscopes and telescopes most frequently used? The fields of medicine, the "hard" sciences (biology, chemistry, and physics), and astronomy use microscopes and telescopes. The theories of lens optics most properly belong in physics courses and physics textbooks. That is where the answers to the preceding Rule of Thumb can be found.

Three problems with camera lenses have been identified:

- Aberrations
- Diffraction
- Distortion

Aberrations

Lens aberrations, or defects in an image produced by a lens, account for a reduction in the resolution of an image. Most, but not all, involve the inability of a lens to focus light at a precise point on the sensor. The result is frequently an impression of "softness" to the image and a loss of clarity of the details in the image. As mentioned previously, the word "aberration" is derived from the name of Ernst Abbe, a German physicist who collaborated with lens maker Carl Zeiss in 1866 to try to solve these problems as they occurred in microscopes in the mid-nineteenth century.

Most lens aberrations occur at the **widest** apertures of a lens. These lens aberrations are usually "cured" by stopping the lens down 2 stops to 3 stops. For instance, if the widest aperture for a particular lens is f/2, then stopping down to f/2.8 and then from f/2.8 to f/4 would almost totally eliminate image problems associated with the aberrations noticed when using an f/2. Actually, it is impossible to totally eliminate lens aberrations. Manufacturing the perfect lens is beyond the skill of lens designers; the best that can realistically be hoped for is that the aberrations are minimized to the point that they do not have an obvious effect on the image.

This is the foundation of Rule of Thumb 5.8, mentioned previously, to avoid the widest apertures of any lens when critical comparisons are being captured. However, as far as crime scene photography is concerned, photographers are usually not tempted to use wide apertures because of their all-consuming concern for maximizing the DOF.

What are the aberrations related to the widest apertures of a lens?

CHROMATIC ABERRATIONS

As light travels through the various lens elements, the different colors in white light will refract differently. The primary colors of red, green, and blue will separate and converge near the sensor at different locations, rather than at one precise point. If these colors do not focus at the same point, the image is noticeably "softer," and the colors may appear to be a bit out of line. Rather than all the colors coming together to form the proper color of an object, a fringe color may be noticed as an unsharp outline of the subject, which can occur two different ways:

as a longitudinal chromatic aberration or as a lateral chromatic aberration. The longitudinal chromatic aberration involves light coming into the lens from directly in front of the camera, which is called on-axis light. The lateral chromatic aberration involves light coming into the lens from the sides of a scene, which is called off-axis light. In both situations, the primary colors will refract/bend to different degrees and come together near the camera's sensor in different areas.

Figs. 5.64 and 5.65 show graphics of both the longitudinal and lateral form of chromatic aberrations.

Designing color-corrected lens elements is a partial solution to these aberrations. Stopping down the aperture is also required to totally "eliminate" this aberration from appearing in an image.

SPHERICAL ABERRATIONS

Similar to chromatic aberrations, the spherical aberration is caused by the different points of light that will converge near the sensor, but this is not related to the colors of white light being refracted by the lens elements. With spherical aberrations, the difference is attributed to the various parts of the lens the light comes through: the outer perimeter of the lens, the midpoint of the lens, or various intermediate distances between the two. With light from different areas of the lens focusing at different points near the sensor, the result is a loss of crispness to the focused image. The image can appear "soft" or a bit out of focus. See Fig. 5.66.

Again, the "cure" for spherical aberrations is to stop down the aperture. Do not use the widest apertures when critical comparison photographs are being taken.

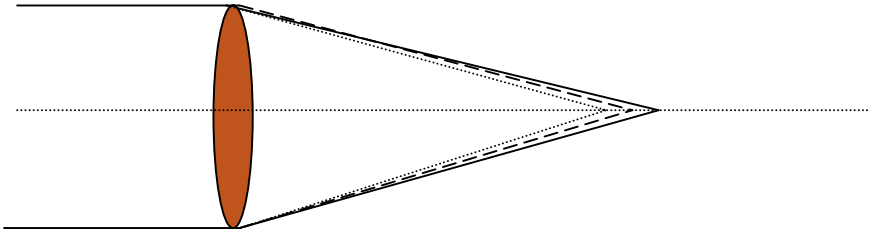


FIGURE 5.64
Longitudinal chromatic aberration.

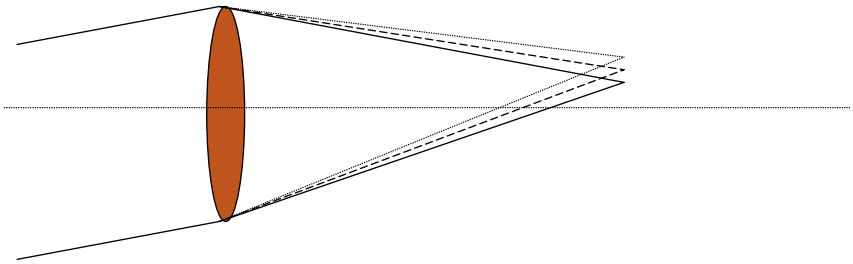


FIGURE 5.65
Lateral chromatic aberration.

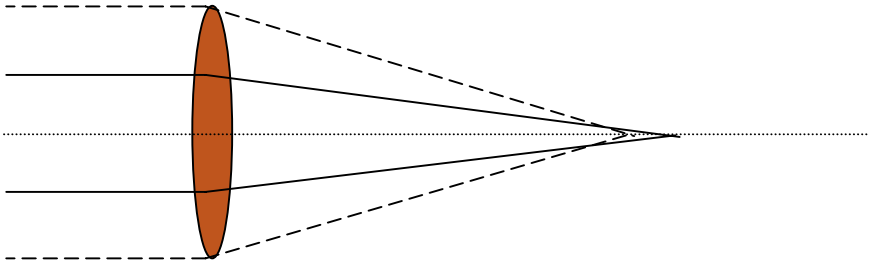


FIGURE 5.66
Spherical aberration.

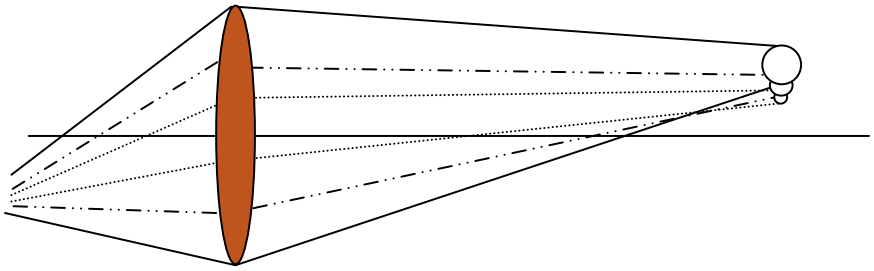


FIGURE 5.67
Coma.

COMA

As spherical aberrations appear somewhat similar to longitudinal chromatic aberrations, coma may seem similar to lateral chromatic aberrations. With coma, light coming into the camera from an off-axis location is focused at different areas of the film plane, depending on what area of the lens it came from: the perimeter, the midpoint, or intermediate distances between those two. See Fig. 5.67.

With coma, the light from a single point in space forms circles of various sizes at the sensor. These overlapping circles suggest the vague shape of a comet with a small trailing tail—hence, the term "coma." The result of coma is a lack of sharpness, contrast, and resolution on the sensor. The "cure" to coma is to use a smaller diaphragm opening or a smaller f/stop.

Other aberrations include astigmatism and curvature of field. Because these are minimized by better lens design and not aperture selection, they will not be described here.

When a lens is adversely affected by aberrations, it is called aberration limited. A lens can also be diffraction limited.

Diffraction

Diffraction is the bending of light when it strikes an edge. The effect of diffraction is a loss of resolution, a loss of edge sharpness, and a loss of clarity in an image. Diffraction is most severe when using the **smallest** apertures of a lens' f/stop continuum. For instance, if a lens has f/stops ranging from f/2 through f/22, the f/16 and f/22 apertures would be most severely affected by diffraction, which is the other basis for Rule of Thumb 5.8. Diffraction is the reason why small apertures are not recommended when images to be used for critical comparisons/examination quality are being captured. When examination quality images are the issue, **the aperture of choice should be f/11 or f/8**.

As an example, Fig. 5.68 is a fingerprint captured with a macro lens set to a 1:1 magnification ratio. A circle shows an area to be enlarged to show smaller details more clearly. Fig. 5.69 shows the area enlarged when an f/8 was used to capture the full fingerprint. Fig. 5.70 shows the same area when the entire fingerprint was originally captured with an f/22. Aside from a slight exposure difference between the two, you should be able to notice that Fig. 5.70 seems noticeably "softer." True, even third level details are visible in both images; Fig. 5.69 is just the sharper of the two images.

Even though capturing a single-digit fingerprint with today's higher-resolution sensors enables a latent print examiner to see first, second, and third level details with both images, the f/8 image is sharper. Spread those same number of pixels out over larger and larger areas, like an entire palm print or a 12″ shoe print, and the loss of detail with an f/22 used to capture the image may become the reason fine detail gets lost in the softness caused by diffraction.

What about the Cardinal Rule to maximize the DOF? When you are trying to capture examination quality images/critical comparisons, it will be necessary to modify this Cardinal Rule a bit from the author's point of view. At times, an image will suffer **more** from diffraction than it will suffer from a lack of the largest DOF range as provided by the smallest apertures. This point cannot be overemphasized. As desperate as you are for the sharpest, clearest, most in-focus image you can get, when you are trying to capture examination quality images, use of the smallest apertures of a lens is counterproductive.

It is perhaps this emphasis on the adverse effects of diffraction that partially separates this text from many others. If you acquire an understanding of diffraction, it may change the way you capture critical comparison photographs, also called examination quality photographs.

With today's higher resolution cameras, it is certainly proper to ask if the higher resolution produced by placing more pixels on the evidence outweighs the loss of resolution produced by diffraction.



FIGURE 5.68
Close-up of a fingerprint.

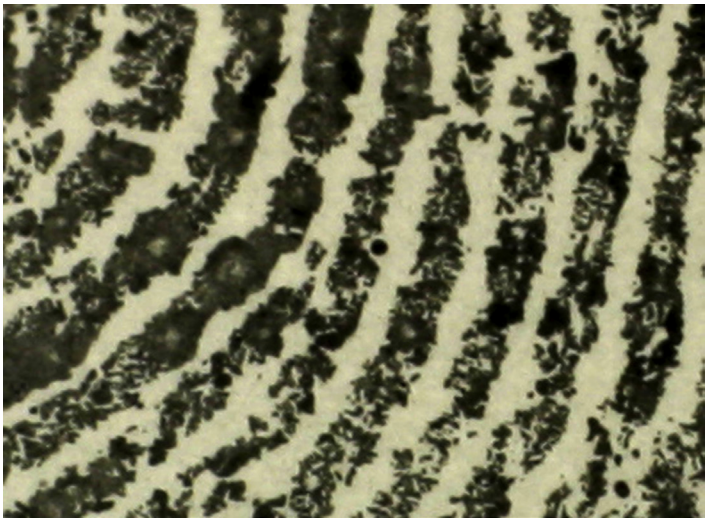


FIGURE 5.69
Cropped area, when the entire print was originally captured with an f/8.

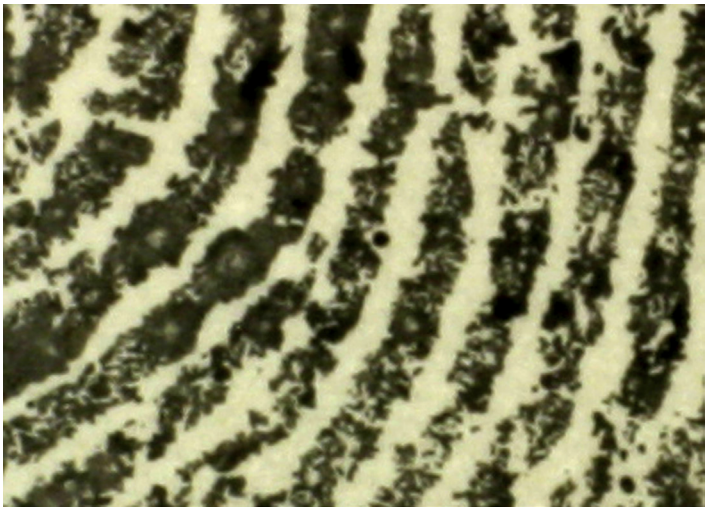


FIGURE 5.70
Cropped area, when the entire print was originally captured with an f/22.

As this text is being written, the NIST OSACs related to friction ridge analysis and shoe wear and tire track analysis are writing drafts on the recommended camera settings to be used when examination quality photographs in their disciplines are captured. Until new OSAC guidelines come out, it is interesting to review the most recent **SWGIT** guideline related to the photography of footwear and tire marks:

SECTION 9 GENERAL GUIDELINES FOR PHOTOGRAPHING FOOTWEAR AND TIRE IMPRESSIONS

Version 1.0 2013.09.27

> Manually focus on the bottom of the impression and close aperture to optimize depth of field **(e.g. generally two stops below the largest f-stop or smallest aperture opening).** (Emphasis added by the author, because of its similarity to this text's **Rule of Thumb 5.8.**)

It must be reiterated that diffraction is not a type of aberration. Whereas quality lens manufacturing can diminish the effects of most of the aberrations, quality lenses will still suffer from diffraction if the smallest apertures are used. Diffraction is based on the physics of light, not lens manufacturing improvements. The only "cure" to the degradation of an image's sharpness because of diffraction is to open the aperture at least 2 stops from the smallest aperture of the lens. Most of the time, maximizing the DOF will be your primary concern at crime scenes. When you are capturing examination quality photographs, minimizing the effects of diffraction is more important than using the smallest aperture for the best DOF.

Several years ago, a specialty lens was being demonstrated to show its remarkable DOF range. Although not a lens designed to be used at crime scenes, it was a part of a digital imaging workstation intended for use by examiners working with latent prints on curved or multilevel surfaces, as well as other types of evidence. Fig. 5.71 exhibits an "impossible" DOF range. A 0.45-caliber casing has been placed on top of a tennis ball, and a scale was placed on the surface supporting the tennis ball. Both the head stamp of the casing and the scale are in focus. Try that with your current macro lens. Fig. 5.72 shows the Fodis Pro 2D Macro Lens responsible for the great DOF in Fig. 5.71.

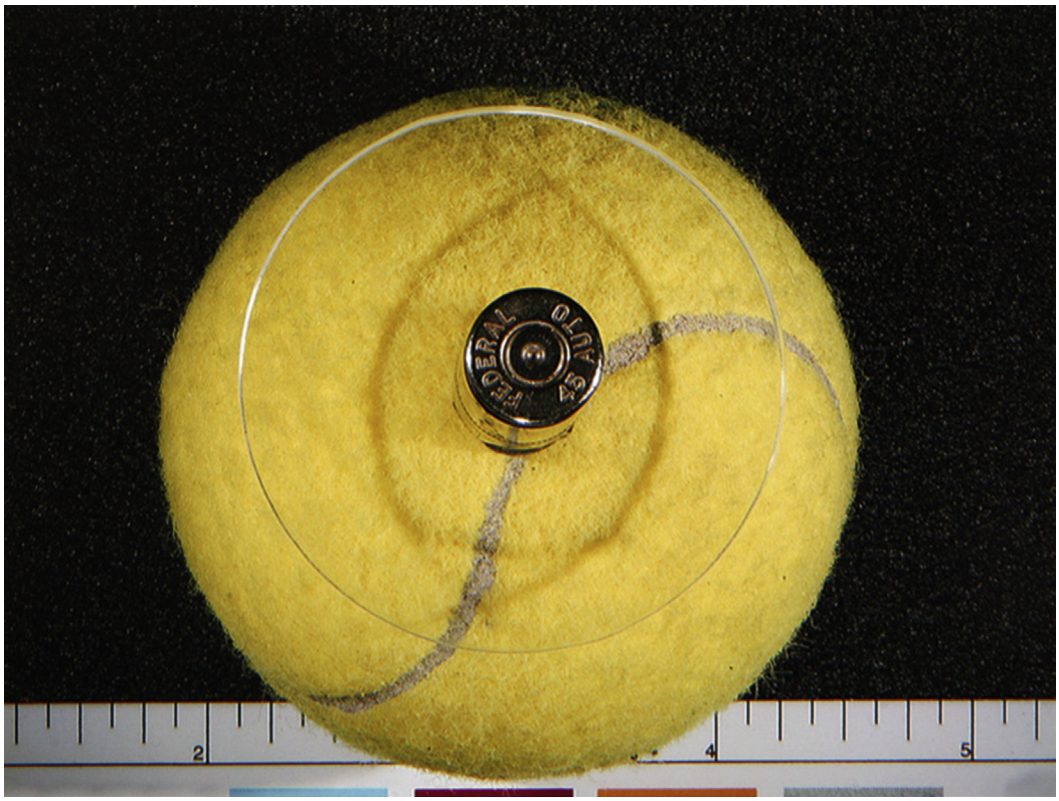


FIGURE 5.71
"Impossible" depth-of-field range.
Courtesy of Tom Beecher, Photografix, Richmond, VA.

The issue was dodged each time specifications on the lens were requested. A comment was made, however, that caught the attention of this author. It was mentioned that the aperture of the lens was opened up 2 stops from the lens' smallest aperture "because of diffraction." Diffraction is not just an abstract idea found in dated physics books. Many professional photographers routinely acknowledge its effect on images. Crime scene photographers will also benefit from a knowledge of its effects and should modify their critical comparison close-up photography procedures because of it.

Aberrations can degrade images captured with the widest apertures of a lens; diffraction can degrade images captured with the smallest apertures of a lens, which can also be expressed by saying lenses can be aberration limited and diffraction limited. The apertures 2 stops to 3 stops in from the extreme f/stops of a lens are called the "sweet spots" of a lens. Depending on the lens, there may be two or three "sweet spot" apertures. If this is so, the Cardinal Rule to maximize the DOF still applies. If a lens' "sweet spots" include f/4, f/5.6, f/8, and f/11, the Cardinal Rule suggests that f/11 is the aperture that both acknowledges the effects of diffraction and maximizes the DOF from the available "sweet spot" apertures.

Distortion

Two other effects that lenses can have on an image are barrel distortion and pincushion distortion. These are usually effects caused by the use of wide-angle and telephoto lenses, respectively.

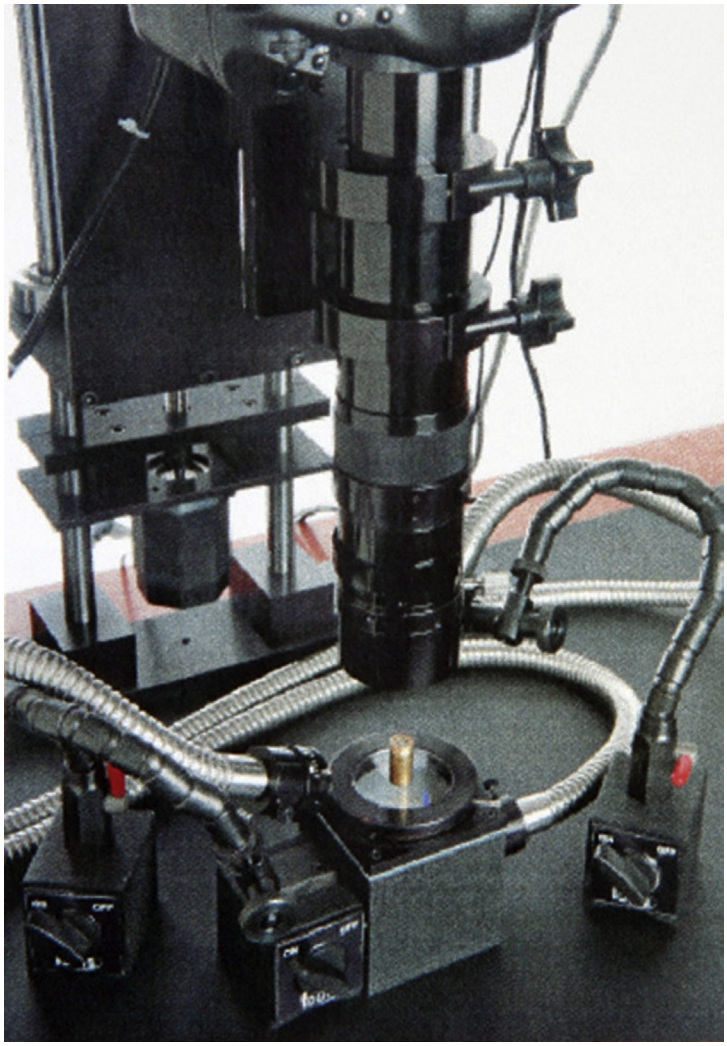


FIGURE 5.72
Fodis Pro 2D macro lens.
Courtesy of Tom Beecher, Photografix, and Richmond, VA. (The second edition of this book included an extended explanation of diffraction, revisiting historical items of interest related to diffraction. These have been removed from this third edition, and placed into the Companion Website for this book for those interested in this material. Available at: http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646.)

BARREL DISTORTION

Barrel distortion is usually an effect of using a wide-angle lens. The result is that straight lines appearing at the edges of an image may appear to be bent outward a bit. Photoshop and other imaging software programs may be able to correct for barrel distortion. Otherwise, not much can be done to avoid this type of distortion other than trying to avoid composing linear objects at the periphery of an image. If it is your current task to compose an entire building that is the site of a crime scene, this may be impossible. See Fig. 5.73. The top and right side of this building appears to be bowed outward.

PINCUSHION DISTORTION

Pincushion distortion is usually an effect of using a telephoto lens. The result is that straight lines appearing at the edges of an image may appear to be bent inward a bit. Again, some imaging software programs may be able to correct for this distortion. It occurs only at the periphery of an image captured when a telephoto lens is used. Fig. 5.74 shows the same spacing between buildings. Both sides of the two buildings appear to be bending toward the center of the image.



FIGURE 5.73
Building showing barrel distortion.



FIGURE 5.74
Buildings showing pincushion distortion.

Many times, the eye may not even notice these distortions because you have become so accustomed to the effects of these lenses. They are, however, inaccurate representations of a scene that you may be asked to explain in court. It is best to be familiar with your "tools" and the effects they will have on your crime scene images.

LEARNING OBJECTIVES, REVISITED

When a layman speaks about wanting a camera with good resolution so that the images produced by it are clear and sharp, that person is usually oblivious to the precise meanings of such terms as "resolution," "acutance," and "sharpness." This chapter explained each of these terms. Also, when you are asked whether a particular camera has sufficient resolution to be used as the primary camera at a crime scene, this chapter provides the means to answer that question.

Most laymen focus their cameras on individual objects. Because photographing crime scenes also requires that large and small areas fall within the DOF range, methods to focus on areas, rather than on individual objects, were discussed and explained.

DOF was defined, and the three factors that affect DOF were explained.

Lens types were distinguished and their differences explained. The effects of each lens type also were presented.

Lenses can suffer from aberrations, diffraction, and distortion, despite the high quality of modern lens-manufacturing techniques. Each was explained. Because diffraction can adversely affect your most critical images, suggestions for minimizing its effect were provided.

DISCUSSION QUESTIONS

1. Briefly explain the nuances of each of these terms: "resolution," "acutance," and "sharpness."
2. Automatic focus has difficulties locking in on some types of scenes. Explain two situations in which it may be better to use manual focusing.
3. Explain the concept of the circles of confusion. How are they related to different apertures? How are they related to different focal lengths?
4. Explain hyperfocal focusing. Include an explanation of how to use the technique when you do have a depth of scale on your lens and when you do not.
5. Explain zone focusing. Include an explanation of how to use the technique when you do have a depth of scale on your lens and when you do not.
6. Explain the camera variables that affect depth of field, that maximize depth of field, and that minimize depth of field.
7. Explain which focal length of lens is most appropriate for most crime scene photography and why this is so.
8. Most of the time depth of field is the most important concern. When does diffraction most affect crime scene photographs? What is its effect? What is the "cure"?

EXERCISES (ALL NONFLASH SHOTS)

1. Create a single-digit fingerprint on an outside surface that is fully sunlit. Place the camera on a tripod; prefocus the lens so it will produce a 1:1 or 1:2 magnification ratio; include a scale; and take a set of three exposures at 0, +1, and −1.
2. Hyperfocal focus on a large outdoor scene where infinity is in the background.
3. Zone focus on an area in front of a building façade that is 30′ from the camera.
4. Zone focus on an area in front of a building façade that is 20′ from the camera.
5. With the widest aperture of the lens, focus on an object 20′ away. Use a 50 mm lens.
6. With the smallest aperture of the lens, focus on the same object 20′ away. Use a 50 mm lens.
7. With the smallest aperture of the lens, focus on the same object 20′ away. Use the widest-angle lens available.
8. With the smallest aperture of the lens, focus on the same object 20′ away. Use the longest telephoto lens available.
9. Place a coin on the sidewalk with the mint designation or date plainly visible. With the camera on a tripod, determine the best exposure using an f/22.
10. Same as No. 9, but use an f/16.
11. Same as No. 9, but use an f/11.
12. Same as No. 9, but use an f/8.
13. Enlarge Nos. 9 through 12 so the mint letter or date is greatly enlarged. Which seems to have the best definition? Why?

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CHAPTER 6

Electronic Flash

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Key Terms

Automatic Flash Exposure Mode
Dedicated Flash Exposure Mode
Fill-In Flash
Flash Calculator Dial
Guide Number
Hard Shadows
Inverse Square Law
Manual Flash Mode
Negative Dust Print
"Normal" Room
Oblique Flash
Painting With Light
PC Cord or Remote Flash Cord
Positive Dust Print
Snow Print Wax
Soft Shadows
Speed of Light
Sync Speed

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the meaning of flash guide numbers;
2. Explain the meaning of the flash sync speed;
3. Explain why it is important for the flash head to duplicate the camera and lens viewpoints;
4. Explain the basics of the manual flash exposure mode and explain some of the drawbacks with the manual flash exposure mode;
5. Explain the inverse square law of light, explain how flash intensities can be determined when the distance the flash travels is known, and explain how the f/stop numbers are derived from these different flash intensities;

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6. Explain the various ways that the flash output could be reduced or softened to provide for precise flash control at different distances;
7. Explain the basics of the automatic flash exposure mode;
8. Explain the basics of the dedicated flash exposure mode;
9. Explain the benefits that these modes have over the manual flash exposure mode;
10. Explain how to bracket in all three flash exposure modes;
11. Explain how to use fill-in flash to obtain a proper exposure with various lighting conditions;
12. Explain how to take photographs using the oblique flash technique;
13. Explain what kinds of situations would benefit from the use of bounce flash;
14. Explain how to compensate for the light loss resulting from the use of bounce flash;
15. Explain when painting with light (PWL) would be the preferred photography technique;
16. Explain how to PWL, when it is possible to flash in toward the scene from two sides;
17. Explain how to PWL, when it is only possible to flash in toward the scene from one side.

Many times, the ambient lighting is not adequate for a proper exposure with the small apertures that will guarantee the best depth-of-field (DOF) ranges. Not only is the amount of light an issue, but the quality of the light is also important. With the wrong type of lighting, unwanted color tints may be noticed in your images, even if the amount of light will ensure the use of small apertures. This may be due to the digital camera's white balance not having been set properly. Electronic flash is the solution to both of these issues. Adding electronic flash to a scene will increase the light levels so that small f/stops can be used. Electronic flash is also color balanced so imagers captured by your digital sensor will be the colors you saw at the crime scene. If you recall, digital sensors will provide proper colors if lit with midday sunlight, electronic flash or when the white balance has been set for the current lighting. And, with a digital camera's white balance set to "flash," unanticipated tints can also be avoided.

Early in the morning, late in the afternoon, at night, or any time photographs will be taken indoors: these are occasions that electronic flash will benefit the crime scene photographer.

GUIDE NUMBERS

When electronic flash units are compared, it is common to inquire about a particular flash unit's **Guide Number (GN)**.

The GN is a means to discuss a flash unit's relative output power. One way to compare several flash units is to compare how much relative light they are capable of throwing into a scene. Several common presumptions come into play when the topic of GNs comes up. GNs can be discussed on the basis of the number of feet or meters that need to be lit. GNs also vary by the ISO currently being used and the focal length of the lens selected. This makes it sometimes difficult to compare flash units, because they tend to advertise with different descriptors.

For example, a quick check of Nikon's and Canon's top-of-the-line Speedlights, as they both call their flashes, will highlight the issue.

A Nikon SB-910 Speedlight is currently selling in the neighborhood of $550. When using a 100 ISO and the flash head corresponds to a 35 mm lens focal length (The flash head itself can be set to correspond to the various focal lengths of a zoom lens.), and the camera is an FX (full size sensor) type, the GN is 111.5′.

On the other hand, the Canon 600 EX-RT sells for $500. Using a 100 ISO, the GN will vary between 85.3 and 196.9′ as the flash varies to accommodate focal lengths between 20 and 200 mm.

In the manual which comes with both flash units, one may be able to find a specific GN for each unit if the camera is set to ISO 100, and the lens is a 50 mm focal length, but they do not make it easy.

Cars can be compared by horsepower or by the miles per gallon they are expected to get. A flash unit's GN is the means by which you should be able to compare various flash units as to their light output. What is one to do? If you persuade a store's staff to let you try out each flash, mount each on an FX camera body, set the ISO to 100 and the focal length to 50 mm. Ask the staff what the synchronization shutter speed is for each camera, and set them both for that shutter speed. Then set both flash units to **Manual Flash Mode** (soon to be discussed) and set both cameras to f/10. Each flash unit should then display the distance their flash will properly expose. Take that distance, multiply it by 10 and that will give you the approximate GN for each flash unit.

What makes this process work?

Knowing a particular flash unit's GN was once, quite a while ago, necessary to determine the exposure settings for the camera. Which camera variables were affected? Because it is often dim when the need to use flash arises, ISO 400 is commonly used in such circumstances; ISO 400 is more sensitive to light, so it can more easily be properly exposed in dimmer lighting situations. Except when examination quality images are being captured, ISO 400 is normally the ISO of choice in dim lighting conditions. If examination quality images are the issue, ISO 100 is recommended because images exposed with ISO 100 can be greatly enlarged for comparisons without the digital noise that may be noticeable with faster ISOs. If the slowest ISO equivalent offered by a particular digital camera is ISO 200, that will have negligible negative effects on the image. But double-check the camera's menu. Sometimes digital cameras offer a default range of ISO equivalents, with an extended range available only through the menu. The extended range frequently offers one or several faster ISO equivalents as well as slower ISO equivalents.

Shutter speeds are not normally an important exposure factor in most electronic flash situations. In flash situations, the optimal shutter speed is usually the synchronization, or "sync," shutter speed. This topic will be fully discussed shortly. At this point, it is sufficient to state that when you are using flash, shutter speeds are not as variable as they are when nonflash images are being exposed.

Returning to the concept of the proper exposure triangle, since we have already set the cameras and the flash units for the same ISO and the same f/stop, now only two exposure variables are left: light in the form of the electronic flash and the f/stop. The GN of the flash unit allows the f/stop to be determined for any particular flash unit, depending on the distance between the flash and the subject matter. Most electronic flash units today have an LED screen that tells the camera operator what f/stop to use for objects at different distances. Before electronic flashes became so user-friendly, it was up to the photographer to do some mental math to determine the proper f/stop to use for any particular distance between the photographer and the subject matter. The formula used was

GN/distance = f/stop

The GN divided by the distance between the flash and the subject matter equals the required f/stop for a proper exposure.

The equation can be altered to read:

GN = (f/stop) (distance)

Therefore, knowing the f/stop set on the camera, and seeing the distance indicated by the flash, we can determine the GN.

This discussion will make more sense if some real numbers are used in an example. Flash units very commonly issued to crime scene photographers have a GN in the neighborhood of 120. If the photographer were 10′ from the object to be photographed, then 120/10 = 12. Because many early cameras did not have an f/12 as a choice, this defaulted to f/11. With a 120 GN flash unit, an f/11 would be required when photographing an object 10′ away.

As a quick comparison guide, here are some common flash GNs:

- GN 160: found on very strong and very expensive flash units.
- GN 120: often considered the "norm" with many law enforcement agencies.
- GN 80: less powerful but still usable as a crime scene flash unit.
- GN 56: a weak flash unit not recommended for crime scene work.
- GN 36: the strength of the built-in flash units on some cameras.

If all these flash units were to be used for the same object 10′ from the photographer, these would be the corresponding f/stops required for a proper exposure:

- GN 160: f/16
- GN 120: f/11
- GN 80: f/8
- GN 56: f/5.6
- GN 36: f/3.5 (about halfway between an f/4 and f/2.8)

You now have a basis for comparing these flash units by their relative flash outputs. A flash with a GN of 160 is so powerful it requires a small aperture, f/16, to properly expose an object 10′ away. The flash with a GN of 56 puts out

less light, so it requires a wider aperture at the same distance. It, therefore, goes without saying that crime scene photographers should not use weaker flashes that require wider apertures. Those wider apertures will result in poorer DOF.

Fortunately, none of this mental math is required now because the LED screen on most flash units directly indicates what f/stop is recommended at any given distance, eliminating all the previously required mental math.

Today, the preceding formula still has one use. If you have lost or misplaced your flash unit's manual and you do not know your flash unit's GN, you can determine it this way.

Make sure the flash is set for ISO 100. Notice which f/stop is recommended for a subject 10′ away, multiply that f/stop number by 10, and that is the GN of your flash unit.

Of course, other ISO speeds will frequently be used when the light is dim. When flash units are compared and GNs are being discussed, the convention of presuming an ISO of 100 is used to avoid all the confusing variables.

You may be asked to recommend new flash unit replacements for your department. If your agency has had success with its current flash units, perhaps you will not need more powerful units. Perhaps many have complained about the output of your current flash units. Knowing what your current flash units are rated is the first step to getting a more powerful unit.

FLASH SYNC SPEEDS

The **sync** (short for synchronization) **speed** is the shutter speed at which cameras should be set whenever an electronic flash is used.

Each camera has one particular shutter speed that has been designated as its **Sync Speed**, which actually is a benefit to the photographer because it reduces the number of photographic variables that have to be considered and manipulated to ensure that a proper exposure has been correctly calculated when using flash.

Check your camera's shutter speed dial if it is an older camera and actually has one. The sync speed is usually indicated by a different color, a lightning bolt may be alongside one of the shutter speed numbers, or an "*x*" may be alongside a particular shutter speed. Typically, today's digital cameras will have sync shutter speeds which vary between 1/60 and 1/250 of a second.

When all else fails, read the manual, obtain a duplicate manual from a dealer, or download a duplicate manual from the Internet to determine your particular flash unit's GN. If no resource is available to determine the particular sync speed of your camera, you can presume that 1/60th of a second will work as the sync speed for your camera. Why? Because, even if another shutter speed has been designated as the particular sync speed for a camera, 1/60th of a second will also work. It is not slow enough to incur blur problems from hand-holding the camera, and it is fast enough that the ambient light present will not normally overexpose the image. It is also comforting to know that since 1/60 is the shutter speed most frequently used with nonflash photography, that same shutter speed can also be used for flash photography as well.

The sync speed is the shutter speed that has the shutter completely open when the flash unit fires. The shutter opens, the flash fires, and the shutter closes shortly thereafter. Because the shutter is open when the flash fires, the entire scene receives the light from the flash, and the scene reflects this light into the camera before the shutter closes.

The use of a shutter speed that is **faster** than the camera's sync speed is to be avoided. On some digital cameras, setting the camera to a shutter speed faster than the sync speed will cause the camera not to work. Some cameras will default to the sync shutter speed if a faster-than-sync shutter speed is set, and some cameras will still work but produce a very undesirable effect. In effect, using a faster-than-sync shutter speed means the shutter will be closing when the flash unit fires. That means a part of the shutter will be covering the digital sensor when the flash fires, and that part of the image will receive no light at all.

Figs. 6.1 and 6.2 show progressively faster and faster shutter speeds being used with flash. More and more of the image is covered by the shutter in these sequential images. In this case, the shutter travels from the bottom to the top. The shutter on some cameras moves from left to right. If you are careful, you will never find out which way your shutter travels by having your images come back covered by the shutter like these images.

What would happen if you accidentally used a shutter speed slower than the sync speed of your camera? In that case, the shutter opens, the flash fires, and the shutter remains open for the designated time before closing. If the shutter speed is not too slow, no adverse effect will usually be seen. Typically, because it is dim when you are usually using

flash, the ambient light is not enough to overexpose the image while the shutter remains open longer. If, however, the shutter speed is very slow, you might notice two negative effects. If the shutter speed is much slower than the normal shutter speed of 1/60th of a second, the image may appear blurred from camera movement.

One other effect may be seen, which is interesting but not desirable. If enough ambient light is in the scene, and movement is present within the scene, you may capture a "ghost" in your image. The shutter opens and the flash fires, freezing any movement within the scene. However, if someone is moving in front of a backlit scene, when the subject moves, the background he or she previously blocked with his or her body can now reflect light into the camera. If the flash froze the subject in this area, the person will be seen in that location. If the subject moves, however, and now light can reach the sensor from an area he or she was previously blocking, then that background is now also exposed on the sensor. When a person is in an area and you can see the background in the same area, it appears as though you are looking "through" that person. A semitransparent person is a "ghost." In Fig. 6.3, the right side of this subject's head is semitransparent from this effect. Eerie, to be sure, but not an effect you would want on an image going to court.

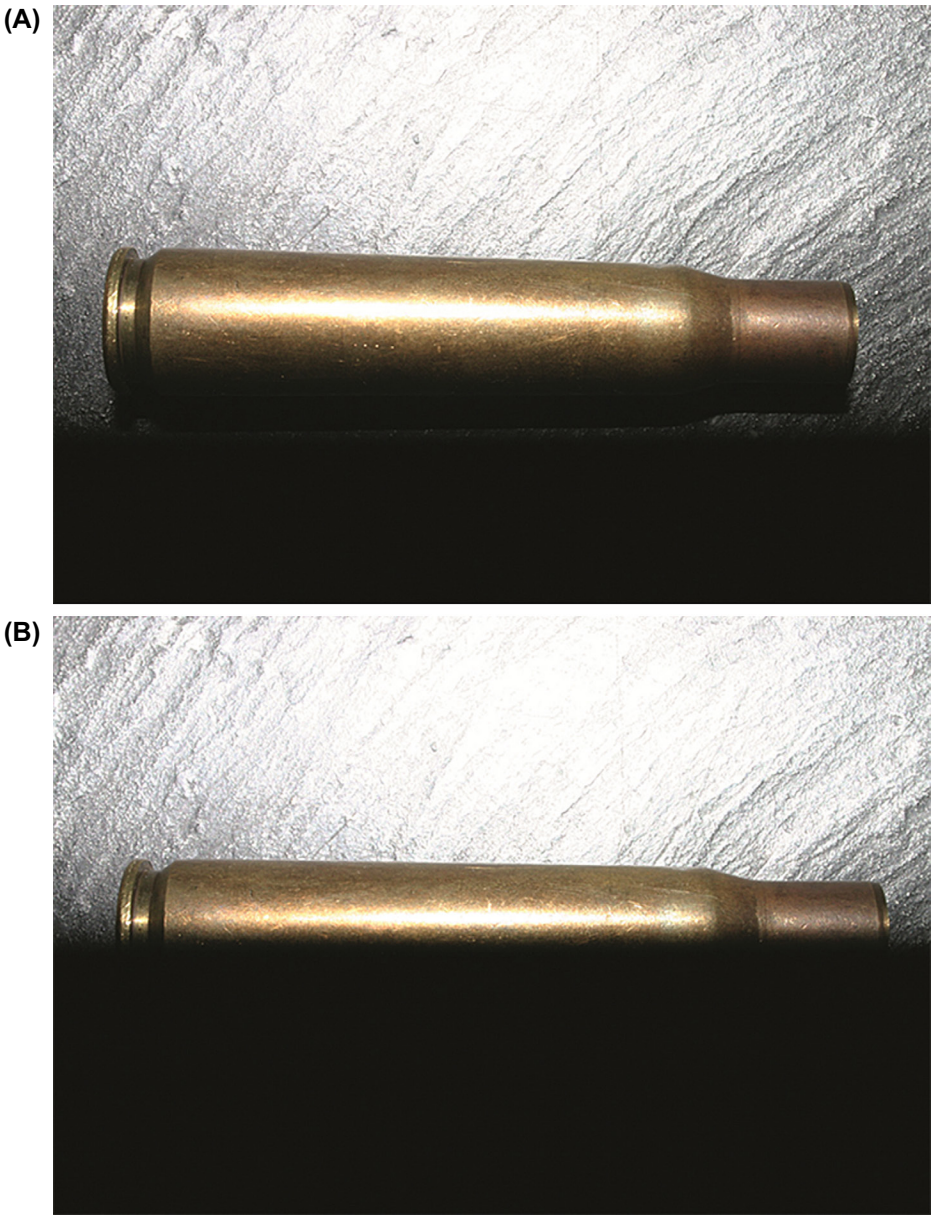


FIGURE 6.1
(A) Sync 1 and (B) Sync 1.3.
Courtesy of Denise Sediq, GWU MFS student.

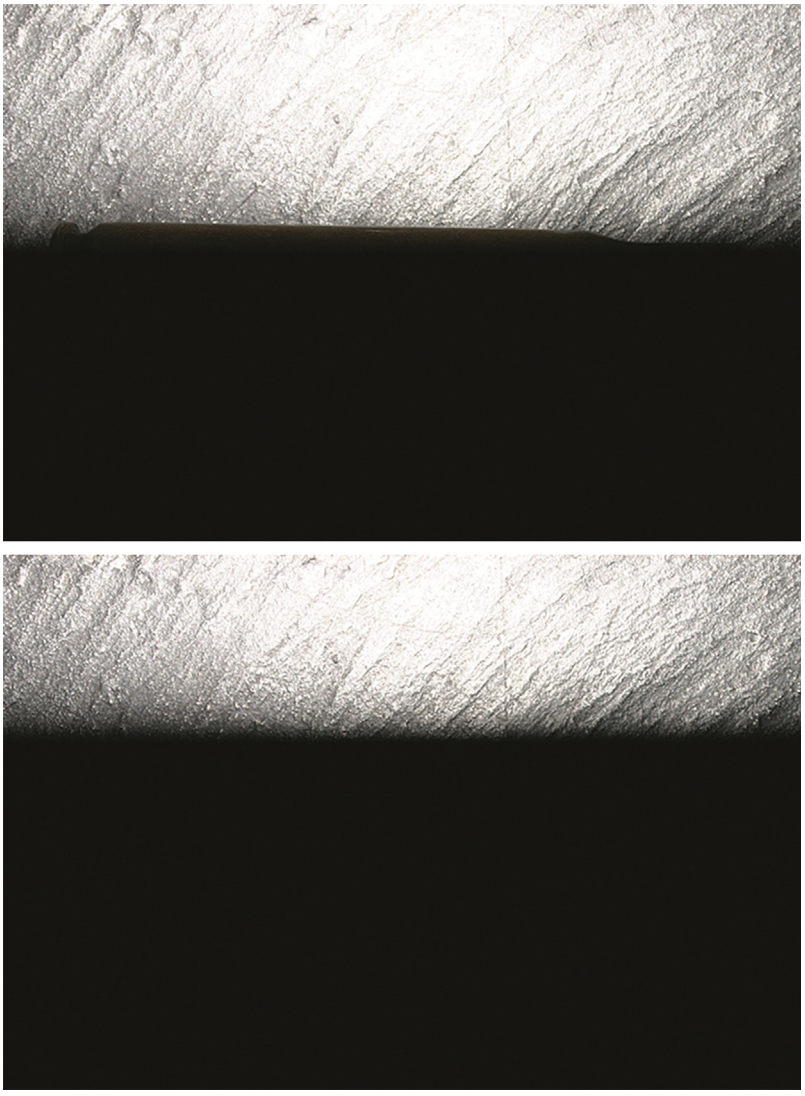


FIGURE 6.2
(A) Sync 1.6 and (B) Sync 2.
Courtesy of Denise Sediq, GWU MFS student.



FIGURE 6.3
A ghost.
Courtesy of S. Keppel, GWU MFS student.

To simplify, whenever using electronic flash, use only the sync shutter speed. Do not be like one crime scene photographer this author knew, examining his latest set of homicide photographs, who noticed one-third of each indoor image was covered by a dark area. When all his victim's body shots were covered by these same mysterious dark areas, he was overheard to say, "They misprinted my photographs again!" Wet-chemistry photo labs and digital processing techniques cannot correct flash photographs that have been taken with the wrong shutter speed.

With nonflash photography, shutter speeds were a major exposure control. Shutter speeds were also the primary control of motion within the scene. With flash photography, shutter speeds no longer serve either purpose. Exposure is now a function of the intensity of the flash unit, with the shutter speed chosen only so the flash fires when the shutter is open. Motion control is now fully taken over by the flash unit's duration. The use of fast shutter speeds must be avoided when using electronic flash. If a shutter speed is faster than the sync speed, the shutter will partially obstruct the film/digital sensor when the flash fires. Fast flash durations now freeze motion. Fig. 6.4 shows an example of a photographer using a shutter speed faster than sync along with flash to freeze the motion of a playing child. The jumping child is frozen in midair by the fast flash duration. A faster-than-sync shutter speed only ensures the shutter will be closing when the flash fires.



FIGURE 6.4
Flash freezes motion faster than sync; shutter speed has the shutter closing when the flash fires.

Many years ago, the common sync shutter speed was 1/60th of a second. Newer camera models are incorporating faster and faster sync shutter speeds. First, some camera makers made a change to 1/125th of a second sync shutter speed. Today, it is not unusual to find top-of-the-line cameras featuring 1/200th and 1/250th of a second sync speeds. Are these a marked improvement? Having the shutter close more quickly after the flash has fired does limit the effects strong ambient lighting can have on the exposure. Because most flash is used in dim lighting conditions, this has a minimal effect on most crime scene photography. It is not recommended to let the flash sync speed be a major consideration when purchasing a camera.

Before leaving the subject of sync shutter speeds, we should discuss one other idea, even though it rarely applies to crime scene photography. When you are shopping for a new camera, the literature may indicate a particular camera has the option of "rear-curtain" sync. Obviously, this feature differentiates this camera from one having only "front-curtain" sync. What does this mean? For this discussion, presume the flash that works with a camera has a normal flash duration of 1/1000th of a second. Also presume the sync speed of the camera is 1/125th of a second. If the shutter will be open for 1/125th of a second, the quicker flash can fire early during that time period or later during that 1/125th of a second time period. Most cameras are designed to have "front-curtain" syncs. That means as soon as the camera's shutter has completely opened, the flash will fire. The shutter will then remain open until the full 1/125th of a second has elapsed, and then it will close.

Rear-curtain sync cameras have the shutter open, some time passes, and then just before the shutter is ready to close, the flash fires. What is the difference? This applies only to creative photography, when the photographer wishes to have creative blurs appear in the photograph. Imagine trying to photograph a speeding car so that its red taillights appear to be elongated streaks behind the car. Over the course of a slow shutter speed, the taillight will streak completely across the image, from left to right. Now it is up to the photographer to determine whether the car will have those streaks in front of the speeding car or trailing behind the car. Naturally, the latter makes more sense. If the camera, however, had only "front-curtain" sync, the shutter would open and the flash would fire immediately, freezing the car at the beginning of the frame, with the red streaks appearing in front of the car. A "rear-curtain" sync would have the shutter open, the car would move across the field of view with the taillights streaking nicely, and just as the car reached the opposite side of the frame, the flash would fire, freezing the car, which is a neat feature, but hardly applicable to crime scene photography.

MANUAL FLASH MODE

Just as nonflash photography has various exposure modes (manual, aperture priority, and shutter priority exposure modes), flash photography has several ways to determine a proper exposure. **Manual flash mode** was the first method of determining the correct exposure when an electronic flash unit was used.

In the manual flash mode, the full power of the flash is usually used each time the flash is fired. Because the flash is used to photograph objects at different distances, the normal way to alter exposures is to change f/stops so the flash output will be appropriate for subjects which are different distances from the camera.

When the lighting is dim, ISO 400 is frequently selected when using the manual flash mode. The one obvious exception is when critical comparison photographs or examination quality photographs will be captured. In those cases, it is still recommended to use ISO 100, if that is available on your camera. If not, use the slowest ISO equivalent available.

The shutter speed will be the sync speed.

The only remaining variables of the proper exposure triangle are the lighting at the scene, which will be the flash unit, and the f/stop selection.

If the full power of the flash is used when 10′ from a subject, and the full power of the flash is used at 20′ from a subject, and every other distance, it is the f/stop selection that would have to be responsible for the ultimate exposure.

The formula GN/distance = f/stop applies here. The **flash LED screen** eliminates the necessity to do any mental math now.

On the basis of the preceding equation, the LED panel now relates various distances with different f/stops.

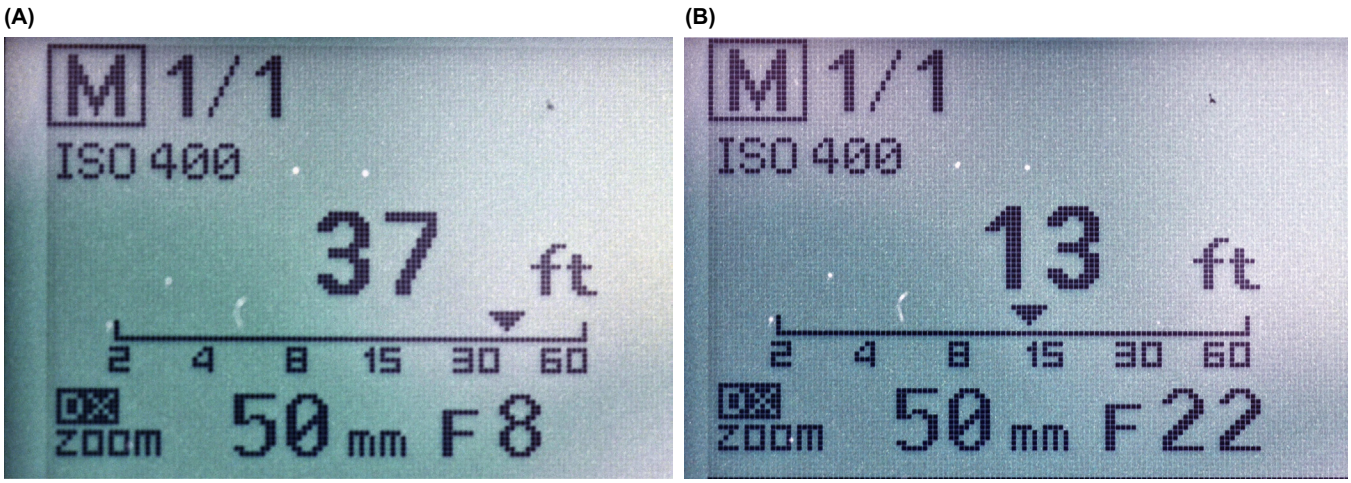


FIGURE 6.5
(A) Manual flash distance for an f/8 with ISO of 400: 37′. (B) Manual flash distance for an f/22 with ISO of 400: 13′.
Courtesy of S. Halter, GWU MFS student.

When it is stated that the full power of the manual flash goes off each time the flash unit is fired, this usually means that the flash fires at its normal duration. The intensity of a flash is related to the duration of the flash. For example, many flash units fire at full strength with their duration at around 1/1000th of a second. That is the most power they are capable of.

If you recall, it was earlier recommended that the f/stops of 8, 11, 16, and 22 be used as much as possible because they produce the best DOF ranges. Let see what the results of those apertures are when used with a 50 mm lens and 400 ISO. Fig. 6.5 shows these results when used with an f/8 and an f/22, respectively. At full manual flash, shown as 1/1, the f/8 results in a flash range of 37′; the f/22 results in a flash range of 13′. With our four apertures optimizing the DOF, we can work within a 13′ and 37′ area just fine. But, what if it is necessary to photograph evidence which is closer than 13′? Many midrange photos and all close-ups will have the camera-to-subject distance closer than 13′. The answer is to diminish the intensity of the full manual flash.

Reducing the intensity of the full manual flash is the same as reducing its duration. So, if the duration of the full manual flash is 1/1000th of a second, changing the intensity to ½ power would change the flash duration to a faster time. Changing the intensity to ¼ in effect changes the flash duration again, and so on. Faster flash is dimmer flash. Many modern flash units can be set between full manual power, 1/1, all the way to 1/128th power. Those are very fast flash durations. Fig. 6.6 shows the full manual flash range being reduced from full power when using apertures from f/8 to f/22, and then with f/22 as the flash intensity is reduced to enable the f/22 to be used at close-up ranges.

Notice how Fig. 6.6 does not include an image with the flash intensity reduced to 1/64, which theoretically would enable the flash to be even closer than 2.2′. This deserves to be a new Rule of Thumb:

RULE OF THUMB 6.1

Most flash units are not designed to be used at distances closer than 2′. When doing close-up photography, resist the urge to bend the elbow of the arm holding the flash unit. Try to keep this elbow straight so the flash does not get too close and overexpose the image.

Fig. 6.7 shows what can happen when the elbow is bent, allowing the flash to get closer to the subject than 2′. The right image demonstrates the use of a locked elbow on the arm holding the flash to avoid having the flash possibly get closer than the 2′ distance, which is the closest distance the flash should be to the subject.



FIGURE 6.6
LED panel indicating distances for the various f/stops.
Courtesy of Craig Wineman, Manager, Penn Camera, Fair Lakes, VA.



FIGURE 6.7
Flash no closer than 2! Keep elbow locked straight.
Courtesy of N. Shah, GWU MS student.

Just to be clear: it is OK to bring the camera with a macro lens as close to the subject as needed to fill the frame with it. However, even if the macro lens is just inches from the subject, the flash should never be closer than 2′. Most flash units will make this apparent to you by not showing a usable distance on the flash LED screen closer than its closest usable distance. This is usually 2′, but some flash units may show a slightly different distance as that flash unit's closest distance. Of course, if the end of the macro lens is just inches from the subject, then this will require the flash to be held at a very oblique angle to the evidence, just to avoid having the lens barrel shadow covering the evidence. This would be an excellent time to use a bounce card on the opposite side of the evidence to bounce some light into the shadow created by the **Oblique Flash**.

Now, with the flash unit used as an exposure variable, if there is the need to bracket with a +1 and −1, it would be good to look at an example as we consider the possibilities. If the original exposure was taken with

ISO 200, sync, f/11 and full manual flash

what considerations affects our choices for changing the exposure to a +1 and −1?

For a +1, these are our options:

- Change the ISO to 400.
- Change the shutter speed to one which is faster than sync.
- Change the f/stop to f/8.
- Can we change the full manual flash to more than "all"? Not by any control on the camera or flash unit. However, it is possible to make the flash brighter than it currently is by moving it closer to the subject. The precise distance to do this is still awaiting the explanation of the **Inverse Square Law** (ISL).

Let us consider the options individually, and if more than one is a possibility, is there an optimal option?

- Changing the ISO from 200 to 400 is an option. Besides changing the exposure, what else is affected? ISOs also affect the ability to enlarge an image, and very fast ISOs suffer from digital noise and an increase of contract. Regarding enlargements, if it is a fingerprint being photographed, no enlargement is needed. If it is a full shoe impression or a segment of a tire track being photographed, then changing to a 400 ISO is counterproductive.
- Faster-than-sync, when possible, is never a good idea. And, some cameras will not allow it.
- Changing from f/11 to f/8 is possible, but it results in less DOF. So, this depends on the subject. If DOF is critical, this is not a good idea. If the evidence is two dimensional, or very flat, then it is OK.
- Moving the flash closer is not an option until we know how to do it properly.

Is there an optimal choice? For small three-dimensional (3-D) evidence, changing to ISO 400 seems better; for larger evidence or for two-dimensional evidence, the f/8 seems a better choice.

For a −1, these are our options:

- Change the ISO to 100.
- Change the shutter speed to one which is slower-than-sync.
- Change the f/stop to f/16.
- Change the full manual flash to ½ power.

Let us consider the options individually, and if more than one is a possibility, is there an optimal option?

- Changing to ISO 100 would provide a better enlargement, if needed.
- Slower-than-sync invites blur if motion is present. Otherwise, it does not have an advantage with flash.
- Changing from f/11 to f/16 is better for DOF, and a wise man once said, "Maximize the DOF."
- Reducing the flash to ½ power results in a reduction in the flash duration, but this is not an advantage here.

Is there an optimal choice? Yes; change to f/16.

Some readers may want to see the effects of changing the full manual flash intensity from 1/1 power all the way to 1/128 power. As we have seen, that is not possible with an f/22 and a 400 ISO, but with an f/5.6 and an ISO of 100 it is possible. Fig. 6.8 shows the sequence.

What if the object to be photographed is in between the distances shown in Fig. 6.8? One can change their distance to the subject to accommodate one of the shown distances, or you can alter the f/5.6 by +1/3, +2/3 (which usually displays as a +0.7), −1/3 or −2/3 until you come close to your current distance.

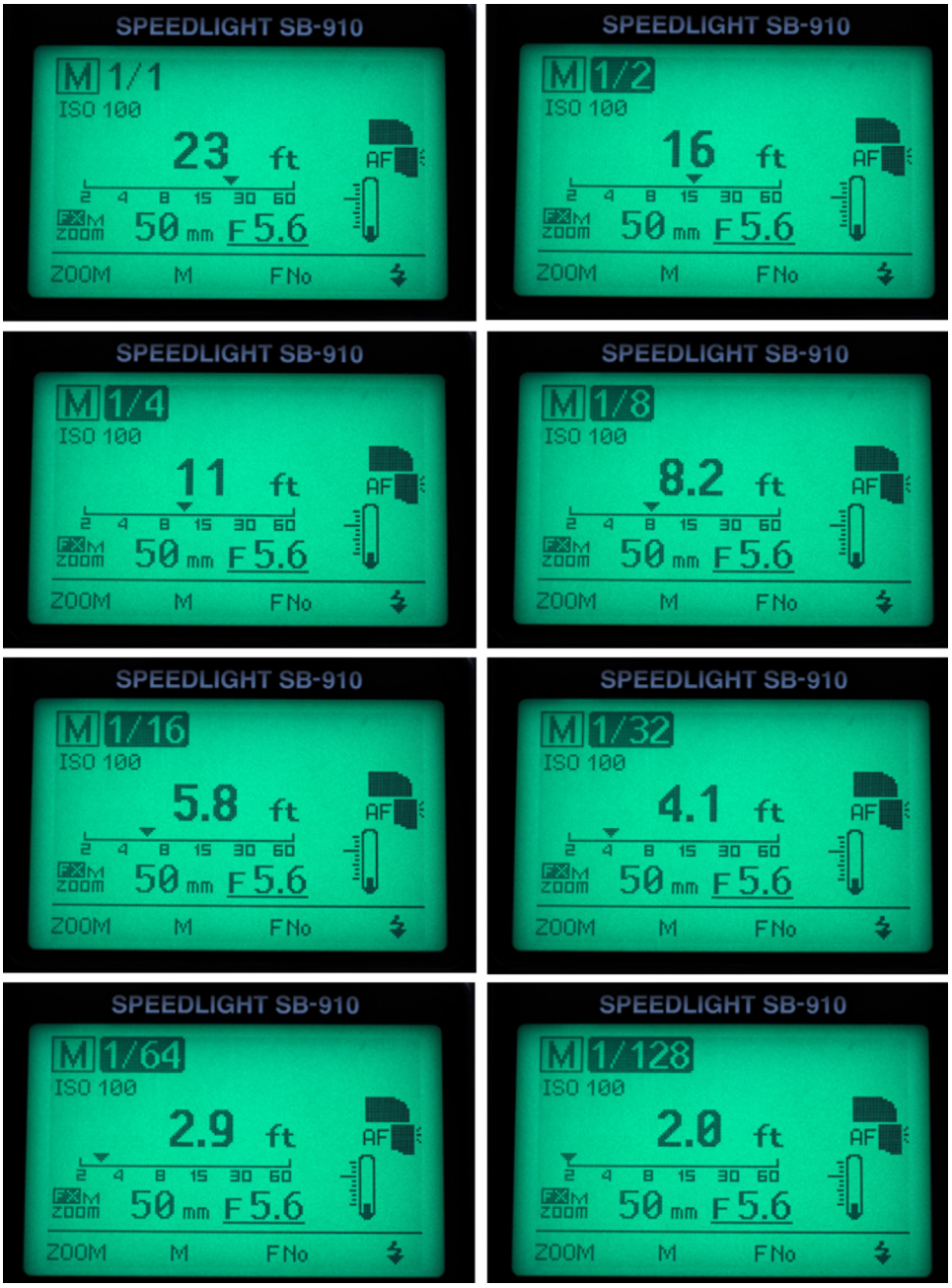


FIGURE 6.8
1/1 manual power to 1/128th power.
Courtesy of R. Taniwaki, Nikon Professional Services.

Recall that we previously stated that the flash now controls motion, whereas with nonflash photography the shutter speed controlled motion. At 1/1000th of a second, or faster, the flash can, indeed, stop most motion. A fast shutter speed is not necessary to freeze motion when the flash is being used. In fact, a faster shutter speed cannot be used with some flashes at all, and with others, it may result in the shutter partially obstructing the sensor when the flash fires.

One other aspect of the manual flash mode also needs to be clarified. If the flash LED suggests different f/stops for different distances, are the exposure error possibilities of the camera meter when exposing light-colored and dark-colored subjects still relevant for manual flash? In other words, when using manual flash, must you still compensate for the tendency of light-colored objects to be underexposed and for the tendency of dark-colored objects to be overexposed? The answer is, "no."

Manual flash provides the right light for the distance. It does not matter whether the subject matter is white, black, or gray toned. Manual flash provides the right light for the distance. The reflectivity variations of the subject are irrelevant when using manual flash. This knowledge can be put to good use many times. Camera meters and flash sensors can often be fooled by the reflectivity of certain subjects. If this can be anticipated, just switch to the manual flash mode and the problem has been solved.

The manual flash exposure recommendations also presume the flash is aimed **directly** at the subject or object to be photographed because direct flash will light the subject or object on the side facing the camera, and this front lighting most effectively reflects light back toward the digital sensor. If you were to remove the flash from the camera's hot-shoe with a remote flash cord and begin lighting the subject or object more and more obliquely, obviously there will be incrementally less and less light reflected directly toward the digital sensor. Manual flash cannot account for these various angles of the flash, so its exposure recommendations apply **only** to direct light situations. In situations in which oblique lighting best captures the details of the subject matter, other methods to determine the proper exposure will be needed, or other flash modes, yet to be discussed, will have to be used.

The "Normal" Room

The theory of manual flash also depends on another presupposition. In an effort to ensure flash equipment works properly under the conditions most people will use it, flash manufacturers put a lot of research and development money into discovering when and where most of their customers will use their equipment. Because every possibility cannot be covered, flash manufacturers uniformly decided to design their equipment for the most prevalent situations. Research indicated most people use flashes when they take photographs of family and friends in their homes. Therefore, most flash units have been designed to work properly in the manual flash mode when it is used in a "**Normal" Room**. What is a "normal" room, and why does this make such a difference?

A "normal" room is a common living room or bedroom. It is about 10′ × 12′ in dimension, it has a white ceiling about 8′ or 9′ high, and it has light-colored walls, rather than walls painted with any other color. When not in a "normal" room, manual flash exposure recommendations will be inaccurate. Why? What is it about this "normal" room that the manual flash depends on?

When the flash goes off, most of its light travels in a direct line from the flash to the subject or object photographed. But, some of the light also moves upward and laterally, and eventually this light will strike a ceiling and/or a wall and bounce inward toward the subject. Manual flash presumes this additional bounced light will be present. When you use manual flash in any other circumstance, the manual flash exposure recommendation will be incorrect. Just three locations are most frequently a problem.

Do not trust the manual flash's exposure recommendation if you are.

1. in a room smaller than a "normal" room,
2. in a room that is larger than a "normal" room, or
3. if you are outside.

In these situations, compensation will have to be made to the exposure recommendation suggested by the flash set to manual mode.

In a room smaller than a "normal" room, there will be more reflected light from the ceiling and side walls, so the exposure will have to be reduced from what is being recommended on the LED screen. This would apply to kitchens, bathrooms, or other small rooms. The exposure reduction necessary is normally ½ to 1 full stop. Bracket to be sure.

In rooms larger than a "normal" room, there will be less light reflected from the ceiling and side walls, so the exposure will have to be increased from what is recommended. This would apply to very large rooms, auditoriums, parking garages, and the like. The exposure increase necessary is normally ½ to 1 full stop. Bracket to be sure.

Outside, there will be no light reflected from ceilings or walls, so the net effect is a much dimmer scene. Begin by adding 1 stop of light as an exposure correction when using manual flash outside. And, bracket. Rule of Thumb 6.2 applies when using manual flash outside.



FIGURE 6.9
Manual flash outside at various exposures.
Courtesy of Carolyn Sikorski, GWU MFS student.

RULE OF THUMB 6.2
Manual flash used outside is at least one stop less bright than what is suggested by the flash LED screen.

Fig. 6.9 makes this point clear. The "best" exposure in this continuum is produced by the +1 manual flash shot. Because the film did not receive additional light from being bounced from side walls and the ceiling, the manual flash had to be set to +1 for the proper lighting. That brings up an interesting question. If manual flash puts out all the light the flash is capable of, how can it put out "more" than all? When manual flash is set to any of the increments it is capable of, say ½ power or ¼ power, it does not put out all the light it is currently capable of producing. Reducing the full manual flash intensity to any of these increments, in effect, allows the flash to save some of the intensity it is capable of. In these cases, you can set a +1 or +2.

There is another method to get a +1 out of a full manual flash, which is supposed to be all the light the flash has available. The answer is to move the manual flash closer to the subject. How much closer is a +1 stop? The answer to that will have to wait for the ISL to be explained, later in this chapter. But, here is a hint: one must first know how far from the subject they are currently standing. That distance, in feet, is converted into an f/stop number, and we should remember that the f/stop numbers are in increments of 1-stop changes, resulting in either a +1 or –1, right? Now you know enough to figure out the answer.

A couple more examples of manual flash exposure may be helpful. In a "normal" room, when the camera is set to ISO 400 and the flash unit has a GN of 120, if the object being photographed is 10′ away, the flash LED will indicate the proper f/stop is f/22. If that same object is at the same distance from the camera but in a kitchen or bathroom, reduce the manual flash power to ½ or ¼ power to compensate for the increased reflections likely to be caused by being in a smaller room. If that same object is at the same distance from the camera but outside at midnight, increase the aperture to f/16, and bracket to compensate for the lack of any reflections from walls or a ceiling.

Photography students frequently question how colored walls or walls with various types of wallpaper will affect a "normal" room. If the walls and ceiling are not painted white or off-white, the results of almost every other variation will be diminished light and sometimes different color tints, and compensations will have to be made.

The Flash Head

Several aspects of the flash head itself have to be understood.

ON-CAMERA VERSUS OFF-CAMERA FLASH

Most camera bodies have a hot-shoe on the top of the camera body, so the flash unit can be directly mounted to the camera. For some photographers, this seems like the optimal placement of the flash, particularly after what was just described about direct manual flash. Having the flash unit connected to the hot-shoe will definitely ensure the light from the flash strikes the subject matter directly rather than from an oblique angle.

The flash head is not exactly aimed the same direction as the camera's lens. They are both aimed straight ahead, with the flash head almost parallel to the line of sight of the lens. When the subject matter to be photographed is at some distance from the camera, the light of the flash will properly light the same area. Does it not make sense, as the subject matter to be photographed gets closer and closer to the camera, that the flash will eventually be aimed above the actual target of interest? Look at Fig. 6.10.

The target is the sticky note on the wall. This makes it obvious that the flash head, in Fig. 6.10, is aimed above what the camera is imaging. Want to see the effect? Fig. 6.11 shows the effect nicely.

Fig. 6.11A was taken 3′ away from a blank wall. First, notice the flash hot spot is above the center of the image. Then notice the underexposed area at the bottom of the wall. With the flash aimed higher than where the camera lens is aimed, you would expect this. Fig. 6.11B was taken 6′ away from the same wall. The flash hot spot is still a bit high in the field of view. A small portion of the bottom of the wall is still a bit underexposed, although most people may not notice this fact if it were not pointed out, especially if the scene is anything other than a blank wall.

Because of these occurrences, a new Rule of Thumb can be suggested.

RULE OF THUMB 6.3

When you are 5′ or closer to your intended subject matter, remove the flash from the camera's hot-shoe, so it can more accurately be aimed at your intended target.

Most flash units do not permit the flash head to be aimed downward. This was the basis for this Rule of Thumb. Some flash units, however, do permit the flash head to be lowered a bit. See the right image of Fig. 6.12, which does allow for a slight downward tilt. Despite this, the Rule of Thumb still applies to most shots closer than 5′.

When the flash unit is removed from the camera's hot-shoe, it must be connected to the camera body with either a **PC Cord** or **Remote Flash Cord**.

We should explain the term "PC cord." Two German camera shutter manufacturing plants are normally credited with developing a camera shutter system that would allow an off-camera flash to fire when the camera's shutter button was depressed: *P*rontor and *C*ompur. The PC cord is an electronic cord, frequently uncoiled, that allows a remote flash to remain electronically connected to a camera so that the flash will fire when the camera shutter button is depressed. Remote flash cords are used with modern cameras and flashes, and these are frequently coiled (Fig. 6.13). Besides enabling the flash to sense when the shutter is tripped, the remote flash cord can also let the flash "know" what ISO setting has been selected, what f/stop is being used, and when the camera's zoom focal length has been changed, so the flash may also accommodate its flash width for the new focal length selected.

A question naturally arises. If having the flash mounted on the hot-shoe is discouraged, how can a photographer maintain the direct flash lighting that the manual flash system presumes? The flash connected to the camera by a PC or remote flash cord can still be aimed directly toward a subject in front of the photographer. Even if the flash is held at arm's length to the side of the camera, the path the light takes to the front of most subjects is still relatively direct. It is only when the flash angle to a relatively close object is more from the side than from the front that problems relying on the flash LED exposure recommendations begin to develop.

As mentioned earlier, most flash units are not designed to be used closer than about 2′ to the subject matter. It is the PC or remote flash cord that allows the **camera** to get as close as necessary to fill the frame with small evidence, while at the same time moving the flash farther away to avoid an overexposure. Each photographer usually goes through a learning curve to get the feel of visualizing the subject through the viewfinder while holding the flash at arm's length while properly aimed at the subject. Many photographs have been ruined by allowing the flash to wander away from the necessary direction while the photographer was busy composing and focusing on the subject. It is not a natural position, but fortunately most photographers pick it up without too much difficulty. The trick is to force yourself to hold the flash with the elbow locked straight. If you allow your elbow to bend, the flash frequently creeps closer than the 2′ distance to the subject, and overexposure is usually the result.



FIGURE 6.10
1.5′ away.
Courtesy of GWU MFS student Tahnee Nelson.

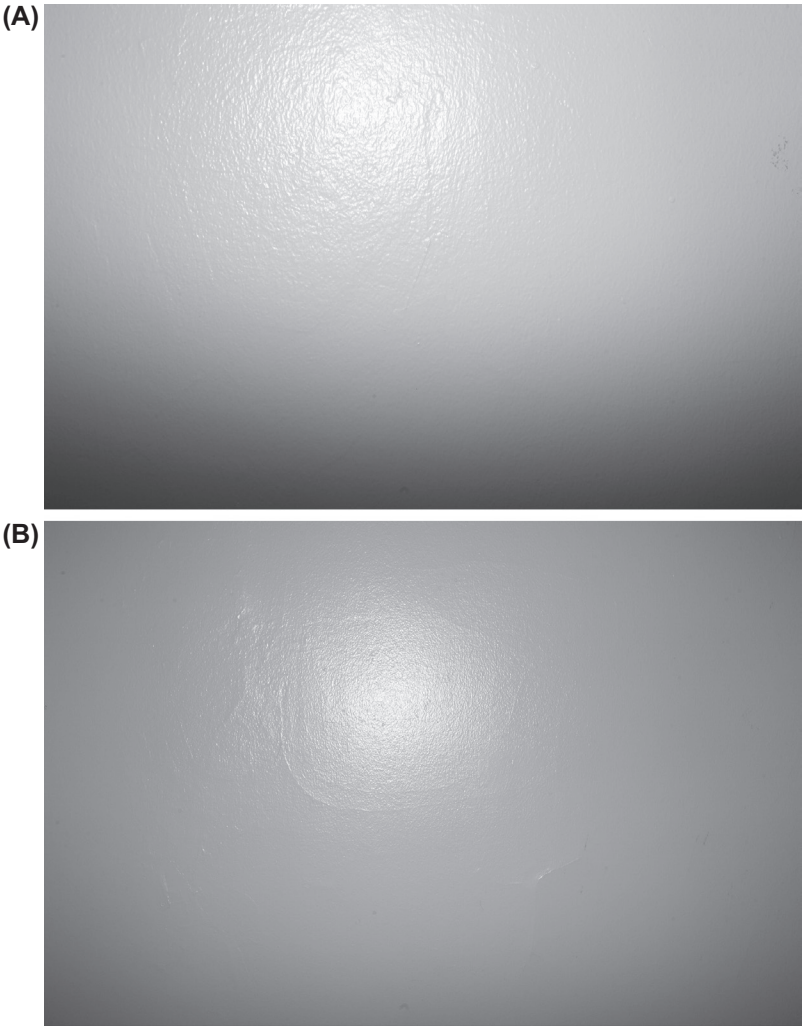


FIGURE 6.11
(A) 3′ away and (B) 6′ away.
Courtesy of GWU MFS student Tahnee Nelson.



FIGURE 6.12
Flash head with downward tilt.
Courtesy of GWU MFS student S. Keppel.



FIGURE 6.13
A camera and flash connected by a remote cord.
Courtesy of GWU MFS student S. Keppel.

Two well-known flash systems enable the flash to be closer to the subject than this normal 2′ distance. Several manufacturers make Ring-Lites, or similar close-up lighting systems. Ring-Lites are round flash units intended to be attached to the end of a camera's lens. Therefore, they can uniformly light a small object without any harsh shadows resulting from flash units held at low oblique angles. A variation on that theme is Nikon's R1 C1 Close-up Speedlight, which features two flash heads that are also attached to the end of the camera's lens. The two separate flash heads can be swiveled around the lens, aimed separately, varied in their intensity, and even removed from their holder and mounted off-camera. See Fig. 6.14.



FIGURE 6.14
(A) A Canon Macro Ring Lite MR-14EX *(Courtesy of Canon, USA.)* (B) Nikon's R1 C1 Close-up Speedlight *(Courtesy of Ron Taniwaki, Nikon Forensic Services.)*.

You might ask about possible benefits of using a flash bracket to remove the flash from the camera hot-shoe (see Fig. 6.15). Many flash brackets are on the market. Their primary purpose is to remove the flash unit from the camera hot-shoe to reduce the possibility of the red-eye effect that comes from using a flash unit close to the camera lens. Red-eye occurs when the light of the flash enters the eyes of subjects, reflects off the blood vessels at the back of the inside of the eyes, and travels directly back toward the camera. Flashes used on the camera's hot-shoe are notorious for creating this effect. So are cameras with built-in flashes. The solution is to separate the flash from the axis of the lens. The closer the flash is to the camera's lens, the higher the probability red-eye will occur. The flash bracket is normally designed to move the flash far enough off-axis that red-eye is eliminated. A secondary benefit of the flash bracket is to make holding the camera and the off-camera flash less awkward.

The flash bracket does, indeed, satisfy both of these needs. Many crime scene photographers sometimes use them. If you believe this bracket will benefit your particular shooting style, then, by all means, use one. The only downside is there will be many times that the flash will have to be positioned at other angles, and taking the flash off the flash bracket and returning it to the flash bracket may prove inconvenient for some. Because of this, many flash brackets allow quick release attachments and then allow quick reattachments to the bracket.

FLASH HEAD AND CAMERA ORIENTATION

Looking through the camera's viewfinder, notice that the field of view is rectangular, just as is the digital sensor. The camera is frequently held horizontally. Or, it can be rotated to provide a vertical viewpoint of a subject or scene. Likewise, the electronic flash head also throws light into the scene in a rectangular fashion. If the camera is held horizontally, the flash head should be held horizontally; if the camera is held vertically, the flash head should be held vertically. With the flash mounted on the camera's hot-shoe, it automatically corresponds to the camera's orientation.

It has previously been suggested that the flash will often better light subject matter that is close to the camera if the flash is off-camera on a PC or remote flash cord. When the flash is disconnected from the camera, it is essential to ensure the camera and flash orientations correspond. Otherwise, the light from the flash will not adequately light the scene, and underexposed edges of the image will be noticeable.



FIGURE 6.15
A flash bracket to hold the flash off-camera.

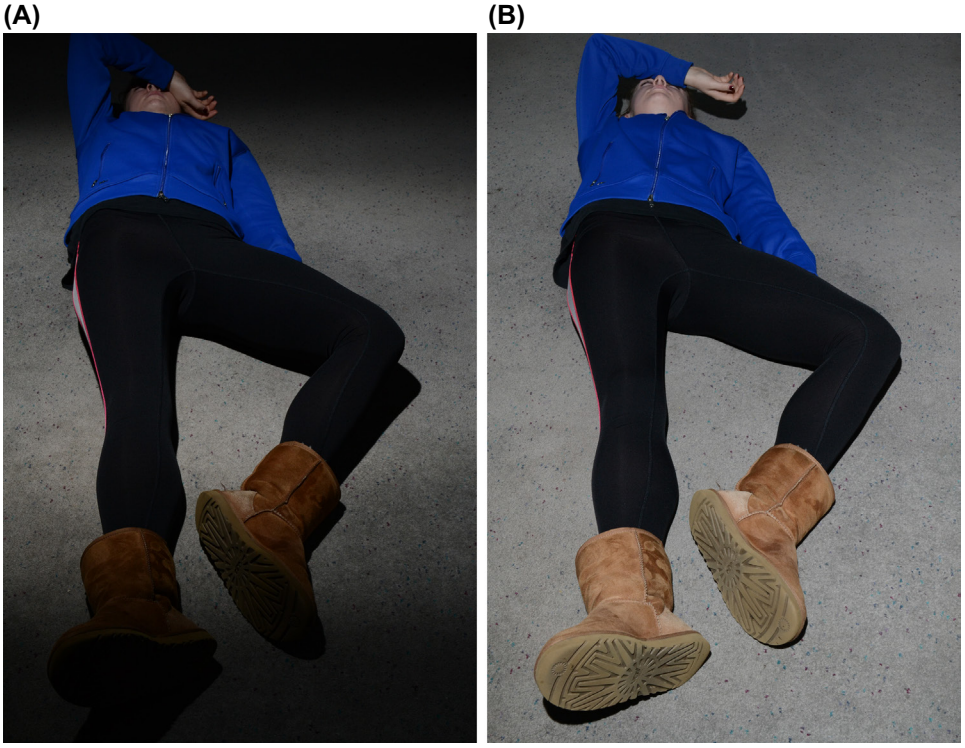


FIGURE 6.16
(A) Camera vertical; flash horizontal. (B) Camera vertical; flash vertical.
Courtesy of D. Maslanka, GWU MS student.

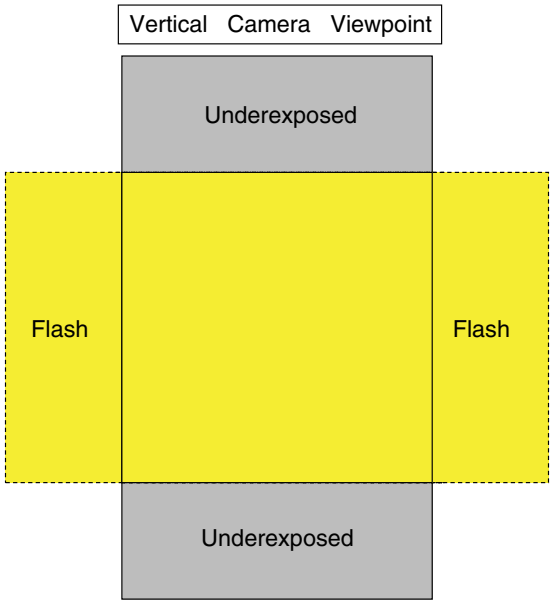


FIGURE 6.17
Camera vertical; flash horizontal.

Fig. 6.16A shows a body photographed with the camera held vertically to accommodate the body's orientation. The photographer, however, forgot to also turn the flash head vertically. The result is that the flash did not adequately cover the viewpoint of the camera, so the top and bottom of the image are underexposed. Fig. 6.17 attempts to graphically demonstrate this misalignment of camera and flash head. Fig. 6.16B shows the correct flash technique: Both the camera and flash head are positioned vertically, so lighting is even over the entire area viewed by the camera.



FIGURE 6.18
Automatic flash head adjustments.

FLASH HEAD AND FOCAL LENGTH

Many agencies provide their crime scene photographers with a zoom lens as the standard lens. With a zoom lens, it may be possible to view the scene or an item of evidence with a wide-angle focal length, with the lens set to 50 mm, or with a short telephoto focal length. Having these options makes a zoom lens very versatile. If dim lighting requires a flash be used to obtain a proper exposure, it is then necessary to have a flash head that has the same versatility. In this case, if the lens is zoomed in or out to either a wide-angle setting or telephoto setting, it is necessary to have the flash head also zoomed in or out to the equivalent focal length.

Fortunately, with today's remote flash cords automatically sending the flash unit all the information regarding the change of the lens' focal length, flash heads automatically zoom in and out as the focal length of the lens is adjusted. These types of flashes usually zoom internally, so their exterior shapes do not change. See Fig. 6.18 as an example of what these flashes would look like as different focal lengths are selected. It is possible to manually set these changes also.

Many flash units also can be used with a wide-angle flash diffuser. This can be a diffuser that fits into a slot near the flash head, clips over the end of the flash head, or can be retracted from the flash head itself to cover the flash face. Flash diffusers can be used with extreme wide-angle lenses. Or, they can be used merely to soften the light of the direct flash when simply diminishing the flash intensity does not produce the effect desired. Very close-up images of reflective surfaces might benefit from such diffused lighting as well. Injuries or wounds to skin would be another situation when diminishing the glare of direct light may be a benefit. Fig. 6.19 shows a wide-angle flash diffuser over the flash.

The white plastic card projecting from the flash head in Fig. 6.19 has a use also but not normally needed by crime scene photographers. Many professional photographers taking photos of faces as a primary part of their jobs do not like the look of direct flash. Among their options is the use of bounce flash off the ceiling, allowing softer light coming down from above. However, professional portraiture photographers appreciate the look of a highlight in the eyes of their subjects. As light travels to the ceiling, some will bounce off the reflector toward the model's eyes, producing this desirable highlight.

Problems With the Manual Flash Exposure Mode

The first type of flash available was manual flash. There was no choice. Today, two other electronic flash exposure modes exist. These other modes were created to solve the perceived problems that the manual flash exposure mode had. They can definitely be thought of as improved flash modes. However, occasions still occur when the use of the manual flash mode will be recommended as the best mode of the available choices. During the course of this chapter, it will be pointed out when one particular mode may be better than the others. To begin, the perceived problems with the manual flash exposure mode should be detailed.



FIGURE 6.19
A wide-angle flash diffuser.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

FREQUENT F/STOP MANIPULATIONS

In the manual flash exposure mode, frequently the full power of the flash goes off each time the flash is used. At 10′, the full power of the flash goes off. At 20′, the full power of the flash goes off. At every distance, the full power of the flash goes off. How are exposures controlled at all these different distances? This is done by altering the f/stop selection or the intensity of the flash. This means every time you move from one position to another position, you have to manually alter the f/stop selection or the flash intensity to maintain a proper exposure. This keeps you very busy. Would it not be an improvement if this constant need to alter f/stops or flash intensity levels could be eliminated or at least diminished? Working a major crime scene is complicated enough. Perhaps a way of simplifying the assurance of a proper flash exposure can be made?

BATTERY CONSUMPTION

With the full power of the flash going off with most every photograph, the batteries in the flash unit do not last long. Replacing batteries frequently can be a very expensive proposition, not to mention an inconvenience. The manual flash exposure mode is notorious for its battery consumption.

You may consider using rechargeable batteries or supplemental battery packs to prolong the life of the batteries, but these efforts represent additional costs too. The basic premise continues: the manual flash exposure mode is hard on batteries.

If a flash mode could be created that does not consume the batteries so quickly, that would be a distinct improvement.

ELECTRONIC FLASH RECHARGE TIMES

If the full power of the flash is used with most photographs, the electronic flash must recharge completely after each use. You must wait for the flash to completely recycle, because if the flash is used again before it has had a chance to completely recycle, only a partial flash fires, and an underexposed image is the result. So, you must wait for the flash to indicate it has completely recycled. Usually, a "ready" light is located on the flash somewhere to indicate it has completely recharged. As the batteries near the end of their normal life, this recycle time begins to get longer and longer, which becomes very inconvenient. A new Rule of Thumb relates to this.

RULE OF THUMB 6.4

If the flash recycle time exceeds 30 s, it is time to replace the flash batteries. Major crime scenes are not the place for you to be waiting long periods of time for the flash to recycle.

Perhaps a new flash exposure mode can be developed that "solves" all three of these problems at the same time? We will get to that momentarily.

Bracketing in the Manual Flash Exposure Mode

Photography students should be reminded that any discussion about electronic flash is still about light, and therefore, we are still talking about exposure "stops." The theory of halving and doubling the light intensity from one exposure situation to another exposure situation is still valid.

When bracketing with an electronic flash, you cannot alter the shutter speed as with nonflash photography. You must look for other ways to change the exposure.

MANUAL FLASH BRACKETING FOR A +1

If the beginning exposure was, for example, ISO 100/1/60th/f/16, you can bracket by changing f/stops, just like bracketing in the nonflash manual exposure mode. Or, you can change ISOs. And, you have the option of changing the flash intensity.

- If the original f/stop selection was f/16, to bracket for a +1 exposure, you can change the f/stop to f/11.
- To change the ISO for a +1 exposure, change to an ISO of 200.
- Bracketing can also be achieved by altering the intensity of the flash output.

How would you be able to get more power than full manual flash? Full manual flash is the most power the flash unit is designed to produce. How would you get more than "all"? As mentioned previously, one way to get more than "all," or a +1 flash exposure, was to be in a situation in which you were already using only a portion of the flash's full power, for instance, if you have the manual flash set to ¼ power. In that case, if you wanted to bracket with a +1, you could then change the flash setting to ½ power while staying at the same distance.



FIGURE 6.20
LED panel indicating distances for the various f/stops.
Courtesy of Craig Wineman, Manager, Penn Camera, Fair Lakes, VA.

Now, the +1 can also be accomplished another way: you can move the flash unit closer to the subject. How much closer? To determine this distance, we need to reexamine the flash's LED panel.

If you recall, the flash LED panel is designed to relate two variables: distances and f/stops. In the manual flash exposure mode, one f/stop can be used for every different distance the flash can be from the subject matter. Notice the following combinations on these flash LED screens: Fig. 6.20:

- f/8 is more or less aligned with 37′.
- f/11 is aligned with 26′.
- f/16 is aligned with 18′.
- f/22 is aligned with 13′.
- f/22 is aligned with 9.2′, when the manual flash is set to ½ power.
- f/22 is aligned with 6.5′, when the manual flash is set to ¼ power.
- f/22 is aligned with 4.6′, when the manual flash is set to 1/8 power.
- f/22 is aligned with 3.2′, when the manual flash is set to 1/16 power.
- f/22 is aligned with 2.2′, when the manual flash is set to 1/32 power.

To achieve a +1 exposure, change the flash-to-subject distance as follows:

- When using an f/8, move to the 26′ distance.
- When using an f/11, move to the 18′ distance.
- When using an f/16, move to the 13′ distance.
- When using an f/22, move to the 9.2′ distance.
- When using an f/22 at ½ power, move to the 6.5′ distance.
- When using an f/22 at ¼ power, move to the 4.6′ distance. And so on.

These are flash-to-subject distances. You can make these changes by actually moving to the prescribed distance, or sometimes you can effect the distance change merely by moving the flash closer to the subject while you remain at the same position. When only short distance changes are indicated, you can simply move the hand holding the flash closer to the subject. For example, to change from the 6.5′ to the 4.6′ distance, you can step forward or remain at the 6.5′ distance while extending your hand holding the flash unit to the 4.6′ distance.

Although this will certainly achieve the desired +1, it means one would have to manually change to a neighboring f/stop, see what that new distance is, move to that new distance, and then change back to the original f/stop. This would be too complicated for most, especially, since there is an easier way. This requires learning the ISL, as mentioned before, but we are now just a couple of pages away. The wait will be worth it!

MANUAL FLASH BRACKETING FOR A −1

If the beginning exposure was, for example, ISO 100/1/60th/f/16, you can bracket by changing f/stops, just like bracketing in the nonflash manual exposure mode. Or, you can change ISOs. And, you have the option of changing the flash intensity.

- If the original f/stop selection was f/16, to bracket for a −1 exposure, you can change the f/stop to f/22.
- To change the ISO for a −1 exposure, change to an ISO of 50, if you have it.
- Bracketing can also be achieved by altering the intensity of the flash output.

Many flash units will allow the manual flash exposure to be reduced by changing the flash LED panel to ½, ¼, or progressively smaller increments. A −1 exposure is achieved by setting the manual flash unit to ½ power. A −2 exposure is achieved by setting the manual flash unit to ¼ power. Some manual flash units can reduce their manual flash output down to 1/128th power, if you recall.

Of course, a −1 flash bracket can also be achieved by keeping the power of the flash at full manual while moving the flash unit farther from the subject, in the opposite increments mentioned in the preceding example.

Enterprising photographers have used a variety of other techniques to reduce the flash intensity. Collecting variations on a theme makes you a more versatile photographer. Students are always told that the more tools they have on their Bat-Belts, the more choices they will have to solve problems that may develop. Options are good. Some of these may prove useful to you also.

When using the manual flash exposure mode, placing one layer of a handkerchief over the flash head effectively reduces the manual flash output by about 1 stop. Caution should be used when applying this concept. Trying two layers and three layers of handkerchiefs over a flash head, thinking the light diminished would be uniform with each layer, may seem logical. Not so. Do not use more than one layer of a handkerchief. Many photographers carry a handkerchief and rubber band in their camera kits, just for this possibility. A variation is to use a layer of toilet tissue. Again, multiple layers of toilet tissue cannot be counted on to yield uniform reduction in lighting levels. White paper towels are too thick.

No handkerchief handy? You can always use your finger to diminish the flash output.

Experience has shown that holding one finger over the flash head effectively reduces the manual flash output by about 1 stop. You might think that this would cause a dark area in the middle of the image, which is the effect if you are too close to your subject. However, the light coming from either side of the finger spreads out and eventually meets in the middle. Do not use this technique if you are about 8′ or closer to your subject. Fig. 6.21 shows the finger a short distance away from the flash. The electronic flash puts out a large quantity of light—enough to be quite hot to the touch, perhaps not enough to inflict real burns with just one flash, but certainly enough to be uncomfortable. A small distance between flash and finger is warranted.

Manually changing the flash zoom head from “normal” to “wide” will reduce the flash intensity, even if the focal length of the lens currently being used is not a wide-angle lens. Using a 50 mm lens but manually setting the flash head to 35 mm will soften the light. As the light of the flash is forced to go wider, there is less light going straight ahead. Take one photo and examine the results on your flash LED. Not enough light eliminated? Try manually setting your flash head to 28 mm, and one of these two should be the look you are looking for.

Just as many filters can be used over the lens of the camera, so too a variety of filters are designed for use with some flash units. Fig. 6.22 shows several flash filters designed to be used with flashes. We are not wanting to create tints over our crime scenes, so the colored filters do not apply to the subject matter at hand. However, the upper uppermost flash filter is a neutral density filter that reduces the flash output by 2 stops. This would be handy to have when needed. The other flash filters are designed for other creative purposes, not relevant to crime scene photography.

Finally, flash will be softened if it is bounced off another surface before arriving at the scene of interest. A section on bounce flash is provided later in this chapter. It is mentioned here just for the sake of completeness.

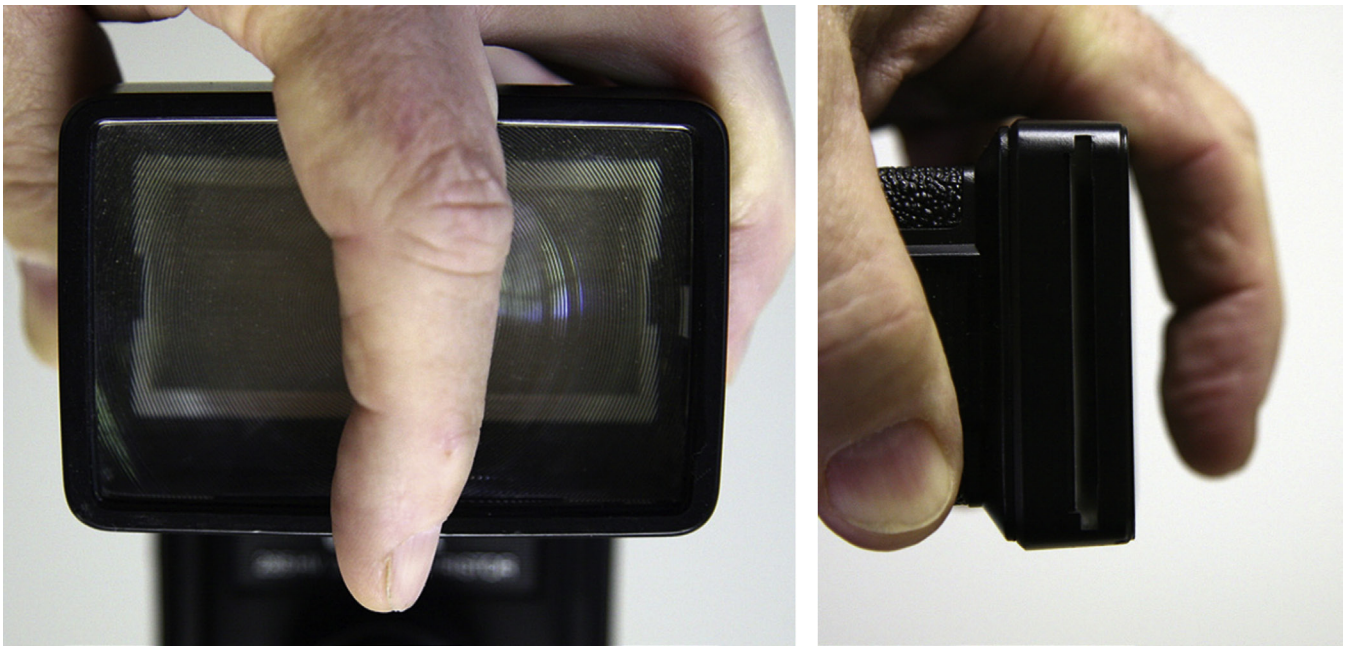


FIGURE 6.21
One finger over the flash.

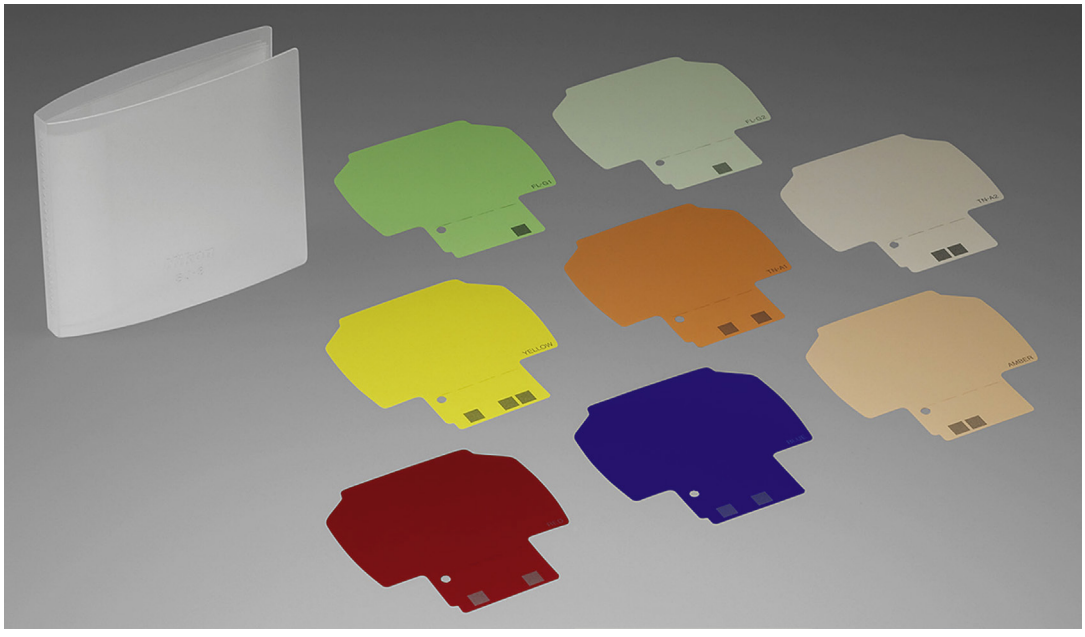


FIGURE 6.22
Flash filters.

THE INVERSE SQUARE LAW

The f/stop numbers are a strange sequence of numbers to be sure. It was previously promised that the f/stop numbers themselves would be explained so they make sense. It is now time for that. Manual flash is based on the relationship between the intensity of an electronic flash and the different distances between the flash and the subject matter being photographed. Recall the equation:

GN/distance = f/stop.

(Depending upon which variable you are trying to determine, this can also be written as: (f/stop)(distance) = GN, or GN/f/stop = distance.)

When the light of the manual flash was brighter (closer to the subject), a smaller aperture had to be used for a proper exposure. When the light of the flash was dimmer (further from the subject), a wider aperture had to be used for a proper exposure. For example, with a 120 GN flash:

- 120/5.5′ = f/22
- 120/60′ = f/2

The **ISL** explains the f/stop numbers, finally. Strictly speaking, the ISL states that as light spreads outward from a point light source, its intensity varies inversely by the square of the distance it travels. What? This is most often expressed in a way very simple to remember:

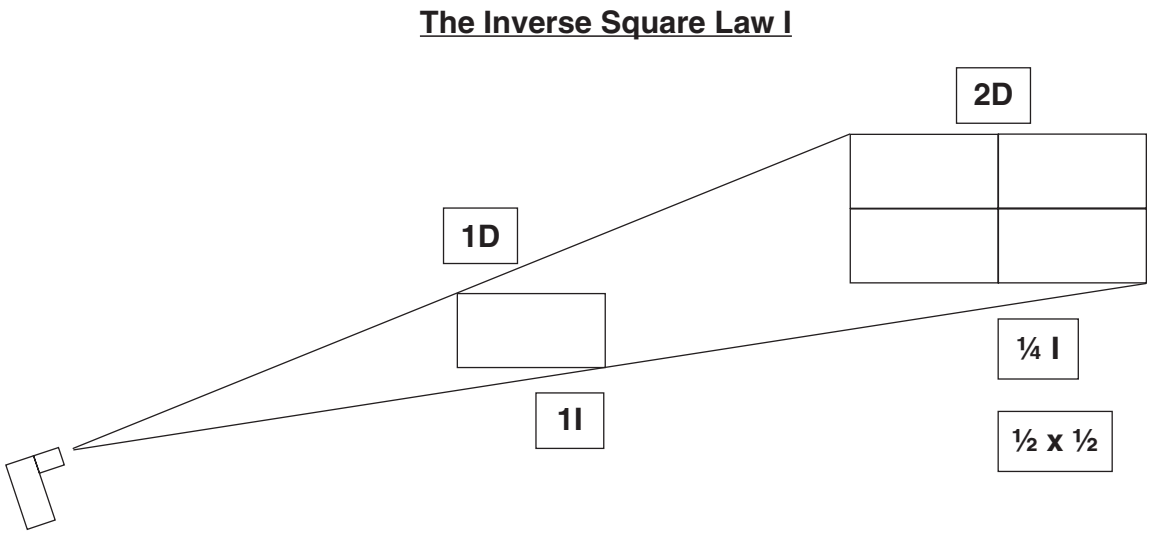
If you double the distance light has to travel, you quarter its intensity.

$$2D = \frac{1}{4}I$$

Although an electronic flash unit is not strictly a point light source, because the flash head itself is larger than such a theoretical point, the ISL also explains light emanating from a flash unit for all practical purposes.

As light travels away from its source, it does not do so and remain a straight line, as would a laser beam. Normal light expands as it travels outward. Its geometric shape would more closely conform to an expanding rectangle of light. As light spreads a certain distance, it is relatively weaker at any one point at the new distance traveled. The ISL allows you to precisely determine its relative intensity at any given distance.

Examine Fig. 6.23. It is the basis of electronic flash exposure determinations in the manual flash mode.



The **Inverse Square Law** shows the relationship between the ***Distance*** light travels and the ***Intensity*** of the light at different distances. As the ***Distance*** light travels is doubled, its ***Intensity*** is quartered. The light at 2D covers four times the area as at 1D, therefore the light is ¼ as bright at any single point. To determine this, take the distance change, 2, and invert it (make it a fraction). 2 becomes ½. Square that (½ x ½), and the result is the ***Intensity*** of the light (¼ I) at that new ***Distance*** (2D). The ***Intensity*** of light at any ***Distance*** change can be expressed by this equation: **I = 1/D².**

FIGURE 6.23
The inverse square law I.

Notice at distance "1D," the area lit by the flash unit would be the single rectangle, and it is one unit. As the distance the light travels is doubled, to "2D," the area the light covers is now four times as great. Covering four times the area, at any one point, the light is only 1/4th as intense. This makes sense. As light travels farther, it is dimmer.

Not only is it dimmer, the ISL indicates exactly how much dimmer the light is. At twice the distance, the light is 1/4th as bright.

Consider an example. If at 10′, an f/22 produces a proper manual flash exposure, what would be the proper f/stop to use for an object 20′ away? In other words, because the light will be dimmer after it travels farther, how much do you have to alter the original exposure settings to achieve a proper exposure at the new distance? Because the light will be dimmer, you expect that the aperture will have to be opened up for a proper exposure. Just how much will it have to be opened up?

The ISL can be expressed as an equation: $I = 1/D^2$. The intensity of light (I) equals the inverse of the distance change squared ($1/D^2$). Because the distance is doubled, from 10′ to 20′, D = 2. I (intensity) = $1/(2)^2$. In this case, I = ¼. Recall the concept of exposure stops being either halves or doubles. Each halving of the light intensity is a −1 stop change. In this case, the intensity has diminished and is currently ¼ as bright as it was. Because ½ × ½ = ¼, then changing from 10′ to 20′ results in a 2-stop reduction of the light. If the original f/stop was f/22, and the light intensity has diminished 2 stops, it will be necessary to open the aperture 2 stops to maintain a proper exposure. At 20′ it will be necessary to use an f/11 instead of the original f/22.

Of course, just checking the flash LED panel would also indicate this, so mental math is not required.

The ISL indicates these changes. The result: doubling the distance that light must travel results in a quartering of the light at that new distance.

The equation, $I = 1/D^2$, allows you to determine the new **intensity** for any **distance change**. Another equation allows you to determine the **distance change** if a new **intensity** is known:

$$D = \sqrt{1}/I.$$

The inverse square root of an intensity change is the new distance. Remember, to determine the intensity when the distance change is known involved squaring the inverse of the distance change. So, it makes sense that if the intensity is known, and we want to now determine the distance change, doing the opposite of a "squaring" (ie, finding the square root) is necessary.

Examples certainly help here:

Find the new **intensity** when the **distance change** is known. For example, if the distance has been doubled, the distance change is 2D. If the distance has been quadrupled, the distance change is 4D. Next, take the inverse of the distance change; make it a fraction. If the distance change is 2D, the 2 of the 2D is made into a fraction: ½. If the distance change is 4D, the 4 of the 4D is made into a fraction: ¼. Now, square the fraction. If the fraction was ½, then multiply ½ by itself: (1/2)(1/2) = ¼. If the fraction was 1/4, then multiply ¼ by itself: (1/4)(1/4) = 1/16. The answer for the first example is ¼ I; the answer for the second example is 1/16 I.

Since exposure stops are either halves or doubles, then each halving of the intensity requires a corresponding +1 stop to maintain a proper exposure. When the distance change was a ¼ I, also understood as (1/2)(1/2)I, then a +2 stop change would be required for a proper exposure.

If we began with 100 ISO, 1/60 and f/22 required for a distance of 10′, then how would the exposure combination have to change if the subject moved to 20′? A (1/2)(1/2) is a 2-stop reduction in the light requiring a 2-stop increase to the original exposure. We could change the ISO from 100 to 400, or, the f/stop from f/22 to f/11.

Since exposure stops are either halves or doubles, then each quartering of the intensity requires a corresponding +2 stop to maintain a proper exposure. When the distance change was a 1/16 I, also understood as (1/4)(1/4)I, or (1/2)(1/2)(1/2)(1/2)I, then a +4-stop change would be required for a proper exposure.

If we began with 100 ISO, 1/60 and f/22 required for a distance of 10′, then how would the exposure combination have to change if the subject moved to 40′? A (1/2)(1/2)(1/2)(1/2) is a 4-stop reduction in the light requiring a 4-stop increase to the original exposure. We could change the ISO from 100 to 1600, or, the f/stop from f/22 to f/5.6.

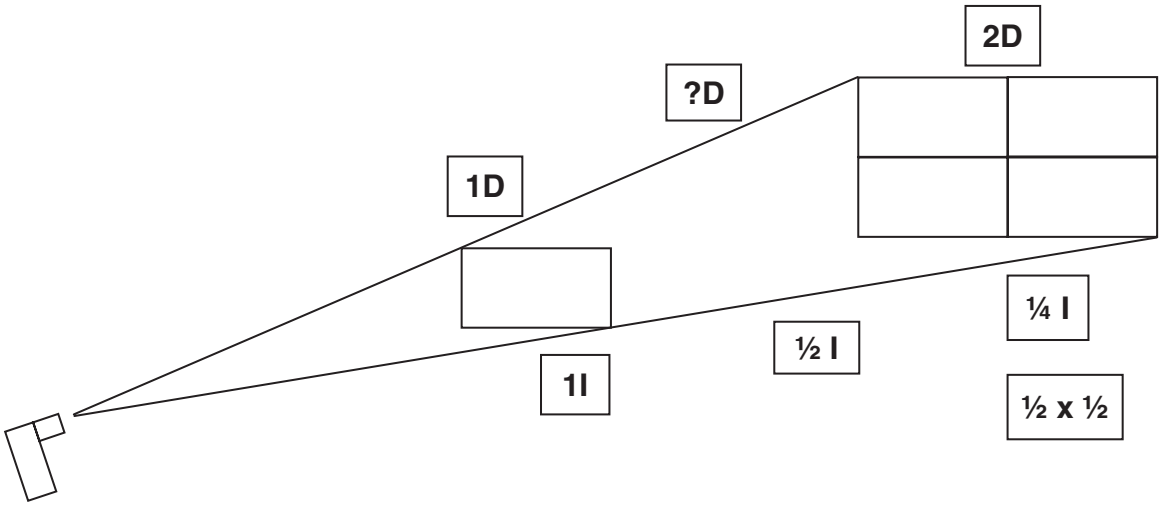
Many photography books mention the ISL is the basis for the derivation of the f/stop numbers. Although they state this fact, they do not explain it. Fig. 6.23 is the beginning of the explanation. If doubling the distance light must travel results in a quartering of the light output (½ × ½) at the new distance, it may make sense to ask at what **distance** would the light only be **1 stop less bright**? See Fig. 6.24. This may seem to be a trivial question because the answer seems obvious. Half the distance between 10′ and 20′ is 15′. That is certainly true, but the question still remains, at what distance would the **light** be exactly **½ as bright**? The equation $D = \sqrt{1/I}$ offers the solution. When the intensity is ½ of what it had been, the inverse of ½ is 2. And, the square root of 2 is 1.414D. Because the original D was 10′, the new D between 10′ and 20′ is 14.14′. Had you not expected the answer to be 15′? Is this just a rounding issue? No. 14.14′ does not round up to 15′. If anything, it rounds down to 14′. Along with the original 1D, you now have a sequence of three distances: 1D, 1.414D, and 2D. Does this sequence ring any bells? This significance may not yet be clear.

If it is not, consider another interesting question. At what distance would the light be 1/8th as bright as the original distance? See Fig. 6.25. Realize that 1/8th is just another way of expressing ½ × ½ × ½, or 3 stops less bright than the original distance. You must return to the equation $D = \sqrt{1/I}$. The inverse of 1/8 is 8; the square root of 8 is 2.82, or 2.8D rounded off. And 10′ × 2.8 is 28′.

Now, look at the sequence progression: 1D, 1.4D, 2D, 2.8D. Does this series of numbers suggest anything? Add this to the mix: each number in the series represents an exact 1-stop diminishing of the light from the previous number. If the series continued, would you be surprised to find out that the next number in the series was 4D? Or, the next number after that was 5.6D? And, the next number was 8D? And, the next number rounded off to 11D (see Fig. 6.26)? Followed by 16D, and 22D?

These are the f/stop numbers. Each "larger" number (further distance) represents ½ the light of the previous number, which is the same relationship the f/stop numbers have with each other. The ISL is the foundation for the derivation of the f/stop numbers.

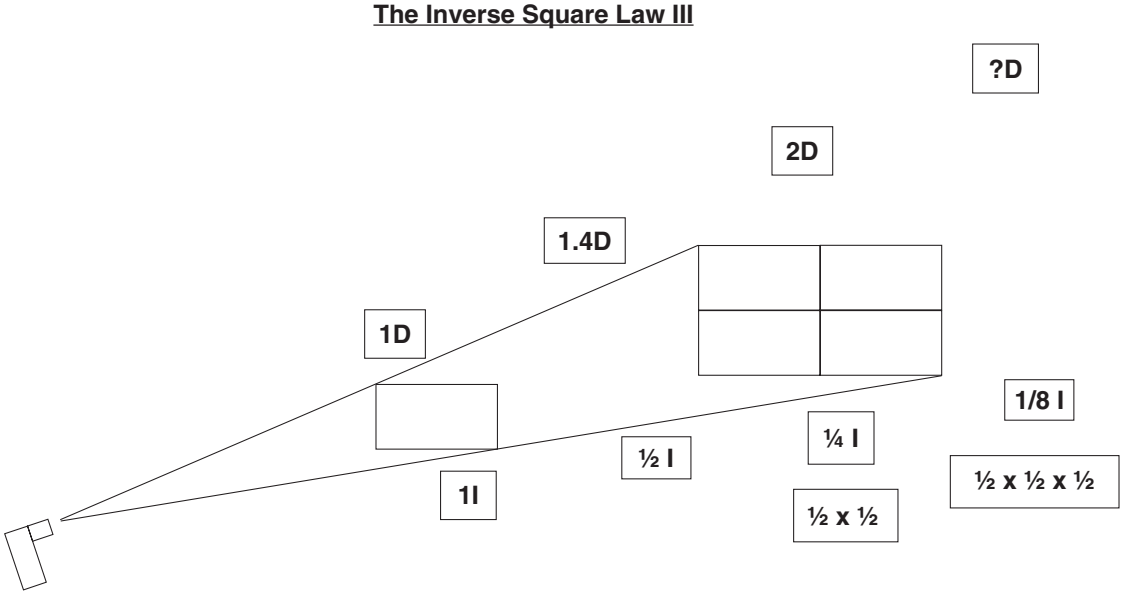
The Inverse Square Law II



If the light at 2D is ¼th as bright, we now realize this is a 2/stop diminishing of the light. Each 1/stop decrease of the light is half the light of the original. A 2/stop diminishment of the light is ½ x ½, or ¼ of the light. The question now is "At what ***Distance*** would there only be a 1/stop decrease of the light: ½ the light?" If, for example, 1D is 10 feet from the flash, and 2D is 20 feet from the flash, at what ***Distance*** would the light be just ½ the ***Intensity*** as at 10 feet? We want to say 15 feet, don't we? But is this correct?

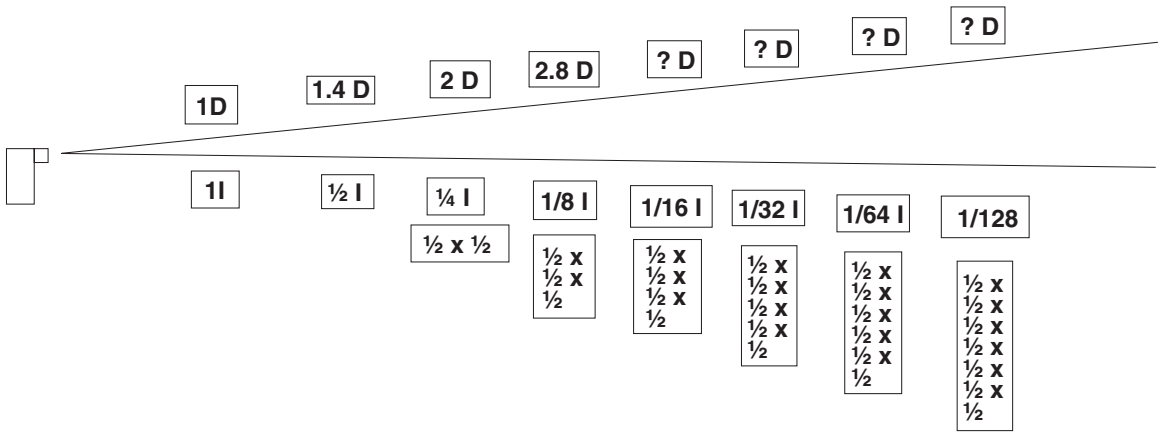
This is how to determine the ***Distance*** when the ***Intensity*** of the light is known. Assume we knew the ***Intensity*** was ¼th as bright at a certain point, and we needed to determine the ***Distance*** that corresponded. Pretend we don't already know the answer: 2D. Beginning with the ***Intensity*** change, ¼, invert it. The result is 4/1 or 4. Take the square root of 4, and that is the distance change, or 2. The ***Distance*** change would be 2D, but we already knew that. Well, if this works with an answer we know, it will also work when we don't know the answer. So, consider ½ I. Invert the ½ and that is 2/1 or 2. Take the square root of 2, and that will be the new ***Distance***. **$D = \sqrt{1/I}$**. In this case, it will be 1.4D, or 14 feet. The progression from 1D to 1.4D to 2D is a curious one, to be sure!

FIGURE 6.24
The inverse square law II.



Now, let us ask ourselves at what ***Distance*** would the ***Intensity*** of the light be 3/stops less bright or 1/8th as bright? Take the inverse of 1/8 and that is 8/1 or 8. Determine the square root of 8, and that is 2.8. So, at 2.8D, or 28 feet, the ***Intensity*** of the light would be just 1/8th as bright. Does the sequence 1D, 1.4D, 2D, and 2.8D look familiar? It should. Maybe one more example will make it more apparent.

FIGURE 6.25
The inverse square law III.



What is the inverse square root of 1/16? 4! What is the inverse square root of 1/32? 5.6! What is the inverse square root of 1/64? 8! What is the inverse square root of 1/128? 11! Now look at the progression: 1D, 1.4D, 2D, 2.8D, 4D, 5.6D, 8D, and 11D! That series you have to recognize! It is the f/stop sequence! **The Inverse Square Law** is the foundation for the derivation of the f/stop numbers! So, the f/stop numbers are exact increments that describe precisely a reduction of the light intensity by ½ at each step. Or, the f/stop numbers can be considered as distances at which the light is reduced by precisely 1/stop.

FIGURE 6.26
The inverse square law IV.

If a manual flash was being used, and the photographer was standing at exactly 11′ from an item of evidence, and the immediate task was to bracket a series of images of the evidence, other than the obvious changes in composition, bracketing could be done by taking three images from 8′, 11′, and 16′. This presumes, of course, the proper exposure had already been determined for the 11′ distance. If a photographer is standing at any one of these distances (1.4′, 2′, 2.8′, 4′, 5.6′, 8′, 11′, 16′, 22′), moving to any other adjacent distance will result in precisely 1 stop more or less light on the image. The f/stop numbers can also be considered as **distances**. They are the precise distances light will travel to be more or less bright by exactly 1 stop.

The ISL also works if the need is to determine either distances or intensities that are closer or brighter than any particular starting point (see Fig. 6.27).

If 10′ was the starting point, where would the light from a manual flash be precisely twice as bright or 1 stop brighter? D = √1/I. The inverse of 2 (twice as bright) is ½, or 0.5. The square root of 0.5 is 0.7D, which is 7′. Where would the light from a manual flash be precisely four times as bright or 2 stops brighter? D = √1/I. The inverse of 4 is ¼, or 0.25. The square root of 0.25 is 0.5D, which is 5′.

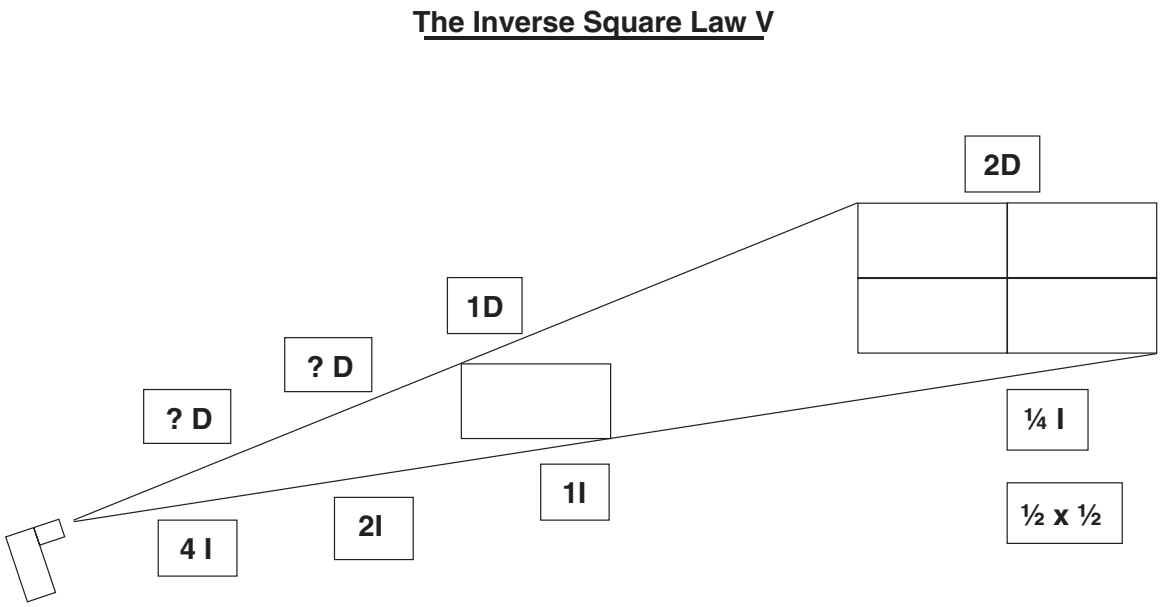


FIGURE 6.27
The inverse square law V.

AUTOMATIC AND DEDICATED FLASH EXPOSURE MODES

As good as the manual flash exposure mode is at helping photographers determine the precise exposure in many situations, it does have some negatives associated with it. Manufacturers of flash units developed two other flash exposure modes specifically aimed at resolving these negatives.

Automatic Flash Exposure Mode

Many flash units have an **Automatic Flash Exposure Mode** capability.

These flash units have a small sensor eye located somewhere on the front of the unit (Fig. 6.28). The sensor eye measures the amount of light reflected from the scene, and when it has determined that enough light has been reflected toward it for a proper exposure, this unit can actually cut short the flash duration to prevent overexposures. Light travels so fast (the **Speed of Light** is frequently expressed as 300,000,000 m per second, or as 186,000 miles per second) that the flash may still be actively projecting light, while some of this light has reached the scene, has reflected off the scene, and has returned to the camera and flash unit—all seemingly in the same instant.

If the right volume of light has been received for a proper exposure, the flash shuts off early. The full manual flash duration is about 1/800 to 1/1000th of a second, depending on the individual flash. If the amount of light for a proper exposure has reflected off the scene and has been sensed by the automatic flash sensor near the camera, the sensor can stop the flash so it would be shorter than the normal 1/800 to 1/1000th of a second. How much reflected light is required? When the sensor receives 18% of the light that reflects from the surface of the scene, the sensor will shut off the flash.



FIGURE 6.28
Automatic flash head sensor.
Courtesy of S. Keppel, GWU MFS student.

Is this beneficial? Yes. Actually, it has three benefits:

- Rather than emitting all the power of the flash, like the manual flash exposure mode does, the automatic flash exposure mode can conserve the flash power not consumed when the flash goes off, when the automatic flash is at any distance shorter than its maximum flash range. For example, Fig. 6.29 compares a manual flash and an automatic flash when ISO 100 is set for both cameras, each lens is set to a 50 mm focal length and each camera is set to an f/5.6
  The manual flash indicates an image will be properly exposed when the flash is 23′ from the main subject. On the other hand, the automatic flash can provide a proper exposure for any distance indicated in the **flash range** shown on the LED screen: 2′ to 23′. When the main subject is 23′ from either the manual flash or the automatic flash, both flash units will provide a proper exposure because both work at the 23′ distance.
  However, the automatic flash unit also provides proper exposures at distances from 2′ up to 23′. How does it do that? When the automatic flash unit is closer than 23′, the light from the flash will be stronger/brighter than it would be at 23′, according to the ISL. The light reflecting off the main subject back to the automatic flash will also be brighter. The sensor eye on the front of the automatic flash unit reads this increased light level and actually cuts the flash of early when it has received sufficient light (18%) for a proper exposure. This flash power that did not need to be used for a proper exposure is retained by the flash. As the automatic flash gets closer and closer to the main subject, and the flash duration is shortened, more and more of the unused potential flash power is retained by the flash.

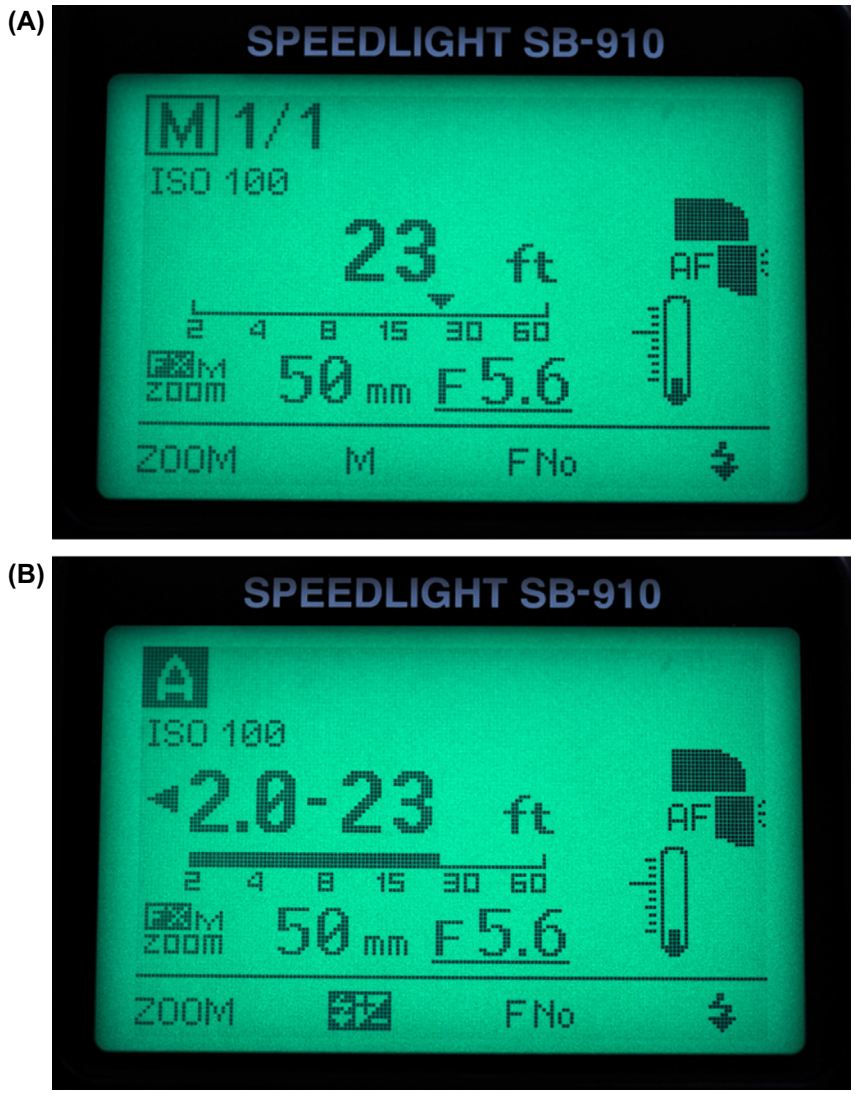


FIGURE 6.29
(A) Manual flash distance. (B) Automatic flash range.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

- This unused flash power results in quicker flash recycle times. Because all the flash power has not been expended, the saved power enables the flash to be ready faster for the next photo opportunity. The flash unit needs to recharge not from zero, but from 20% to 80% of a full charge, depending on the distance between the flash and the scene. Therefore, it takes much less time to fully recharge.
- This unused flash power prolongs the life of the batteries as well. They last longer because they do not have to fully recharge the flash unit every time the flash is fired.

In the manual flash exposure mode, an f/22 may be just right for an 11′ distance when using an ISO 400 and a flash rated with a 120 GN. Any closer, and the photograph is overexposed; any farther, and the photograph is underexposed. With an automatic flash unit, the range for an f/22 might be 2′ to 11′. Anywhere in that range, the f/22 would produce the proper exposure. At 11′ the flash works just like the manual flash exposure mode would, expending all the power of the flash. But at closer distances, the flash durations get shorter and shorter, recycle times are quicker, and the battery life improves.

Now, in the automatic flash exposure mode, the f/22 can be used for close-ups, rather than having to be manually diminished until a 2′ distance shows on the flash LED screen. Using an f/22 for close-ups provides the best DOF for close-ups when it is really needed.

Because the concept of DOF has just come up again, this would be a good time to point out the obvious: The best f/stop for DOF distance, f/22, just happens to be the worst f/stop for flash distance, about 11′ in the manual flash exposure mode, and 2′ to 11′ in the automatic flash mode. When using flash, you continually have to compromise DOF for proper lighting distances. With a 120 GN flash, an f/8 will get you only about 30′ of light from your flash.

The first two editions of the book took this last sentence as gospel and stated that since we did not want to change to an f/5.6 to achieve a greater flash distance, then f/8 and its resulting 30′ of flash distance were the best we could hope for. This translated into a previous Rule of Thumb to consider any dimly lit scenes beyond 30′ to be either underexposed with the f/8 or suffering from the shortened DOF of an f/5.6.

At one time, when 400 ISO film was the tool most of us used in large dimly lit crime and accident scenes, this was true. However, with digital cameras in use everywhere now, our previous chapter on exposure indicated that ISO 800 produces images just as good as ISO 400 had produced and can now be regarded as "normal." Depending on your particular camera, you may find that ISO 1600 also produces an acceptable image as well. (Do tests with your camera to determine if you find the images produced with an ISO of 1600 are acceptable to you.) Now, however, since ISO 800 produces acceptable images, and it is relatively easy to change from ISO 400 to ISO 800, when attempting to maximize the distance we can have both well-exposed images and large areas which fall within our DOF ranges, 30′ is no longer this distance. Depending on the GN of your flash unit, changing from ISO 400 to ISO 800 will increase your flash coverage, using an f/8, up to between 42′ and 46′, depending on the GN of your particular flash unit.

Because it is the continued goal to have crime scenes both properly exposed **and** in focus, when you are using flash, a new Rule of Thumb is relevant. This Rule of Thumb presumes two things: you are using a 120-ish GN flash, and you are using a single flash burst to light your scene. Later in this chapter, you will learn how to use multiple flash bursts to light large crime scenes. If you have a flash unit with a stronger GN, the 42′ to 46′ distance may be extended further.

RULE OF THUMB 6.5

When you are using flash, pretend the world beyond about 42′ to 46′ does not exist, because beyond that, the scene will either be underexposed or a wider aperture will have to be used, which results in a smaller depth of field range.

This simply means that if you need to light a scene longer than 42′ to 46′, wider apertures will be required, which begins to severely impact your DOF range. If not wide apertures, then even faster ISOs will be needed. But, then we have to remember that as the ISOs get faster and faster, digital noise will become more and more apparent. What should one do for larger dimly lit scenes? You will eventually be presented with two solutions for this later in this chapter.

If the automatic flash exposure mode has the preceding three benefits, is there any downside to using this flash mode? Yes. Because a sensor eye is reading reflected light from the scene, sometimes the sensor eye might be "fooled" about the amount of light necessary to properly expose some scenes. The automatic flash exposure mode

can be "fooled" by the same situations that will "fool" the exposure meter in the camera body when used for nonflash shots. Overly bright scenes will reflect more light than a "normal" scene, causing the flash to be shut off early, and underexposures will be the result. Overly dark scenes will reflect less light than "normal" scenes, causing the flash duration to be prolonged, resulting in overexposures. The flash sensor can be "fooled" exactly the same ways the camera body exposure meter was fooled under certain circumstances. What can be done in these situations? You can either remember the exposure recommendations earlier suggested for nonflash photography, or in these situations, you can switch to the manual flash exposure mode, which does not make its exposure recommendations on the basis of reflected light.

However, these situations are the exceptions to the rule. The automatic flash exposure mode will benefit crime scene photographers under most situations and should be used as the primary flash mode most of the time if the only other option is the manual flash exposure mode.

You previously learned how to bracket in the manual (nonflash) exposure mode and the automatic (nonflash) exposure modes. You also learned how to bracket in the manual flash exposure mode.

If you recall, in the manual (nonflash) exposure mode, bracketing was accomplished by manually changing the f/stop selection. For example, if the original exposure was ISO 100, 1/60th and f/16, +1 and −1 exposures would be done with f/11 and f/22, respectively.

In the automatic (nonflash) exposure modes, bracketing was accomplished by changing the exposure compensation dial/button to +1 or −1. This applied to the program automatic exposure mode, the aperture priority automatic exposure mode, or the shutter priority automatic exposure mode.

In the manual flash exposure mode, bracketing was accomplished by changing the f/stop settings, by changing the flash intensity, or by changing the flash-to-subject distance.

Now, if you are using an automatic flash exposure mode, how is bracketing done? Just as the automatic (nonflash) exposure modes used exposure compensation, there is exposure compensation for automatic flash exposure modes as well. But, it is not the same exposure compensation dial/button on the top right of the camera body, or as indicated on the camera LED screen, which is used with flash.

The flash exposure compensation can usually be found on the flash LED screen. Fig. 6.30 shows two different Nikon flash LED screens where the exposure compensation symbol is located in two different places. With buttons or dials, these areas are selected, and then the photographer can choose which increment of exposure compensation to set the flash for: this can sometimes be as much as a +5 to −5 setting. Fig. 6.31 shows a Canon flash LED screen where the exposure compensation is set by first pushing the "Select/Set" button, circled, and then pushing either the "+" or "−" buttons for the desired increment.

Look at a couple of practical examples. Because you are using flash, you probably have ISO 400 set on the camera. Automatic flash exposure modes provide ranges within which one f/stop can be used. Exposure is controlled within these ranges by the flash sensor eye reading the reflected light coming from the subject and then altering the flash duration so that an 18% exposure is obtained. If you are in the close end of the flash range, the flash duration will be cut short when 18% reflected light has been received. The flash duration will be increased as the flash-to-subject distance increases, until at the far end of the flash-to-subject range, the flash duration is the same as a full manual flash. In other words, in the automatic flash exposure mode, the flash duration can be less than the full manual flash output, or it can be the equivalent of the full manual flash output. Automatic flash output cannot be more than the manual flash output (unless you move the flash unit closer to the subject, as mentioned above).

For a −1 flash bracket when using an f/22, you must move to another distance, outside the automatic flash range, according to the ISL. For example, because about 11′ is the far distance of the automatic flash range, when using an f/22, consider that 11′ distance as an f/11. If you were using an f/11 and needed to dim the lighting precisely 1 stop, how is this to be done? This would be accomplished by changing the f/stop to f/16. So, if you were to move from 11′ to 16′, you would reduce the flash effect on the scene by precisely 1 stop. Or, because 11′ is the far end of the f/22 automatic flash range, and it is equivalent to the manual mode exposure mode, you could put one layer of a handkerchief over the flash head to reduce the flash output by 1 stop.

If you were not at the extreme end of the auto flash range and needed to achieve a −1 bracket, one option is to switch to the manual flash mode and determine a −1 exposure for the precise distance where you currently were positioned. For instance, if you were 8′ from your subject, the correct manual flash setting would be ½ power. Then, changing the flash to ¼ power would be a −1 flash exposure.

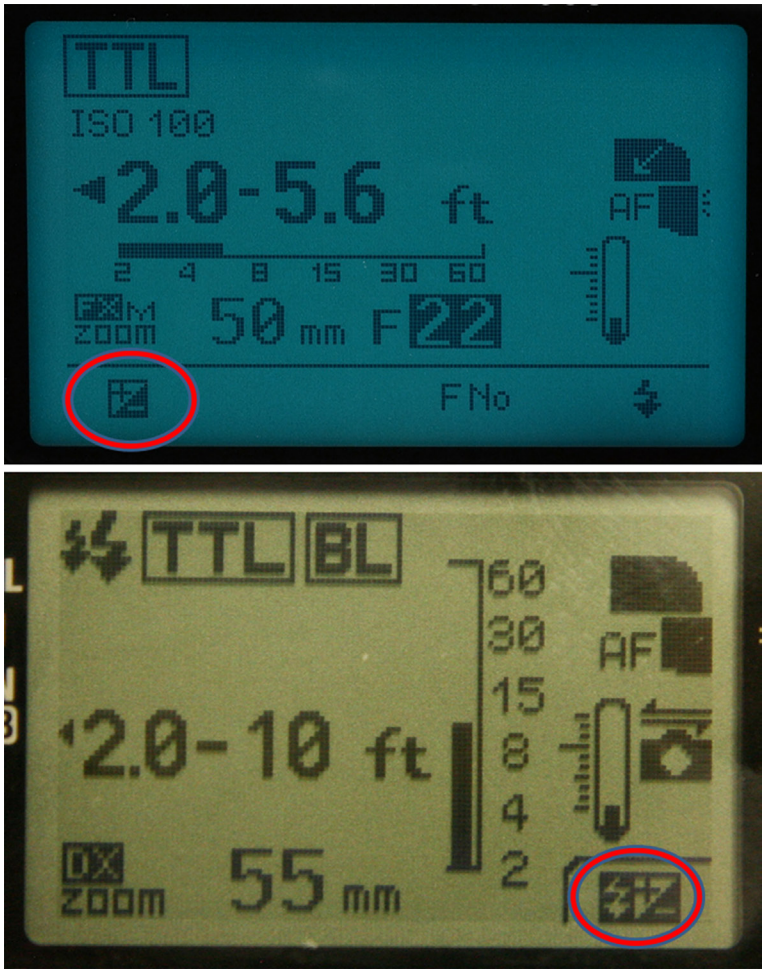


FIGURE 6.30
Flash exposure compensation indication.

Some flash units also have a flash exposure compensation dial or button, which works by affecting the flash duration/intensity. A −1 flash exposure compensation will shorten the flash duration, much like the manual flash mode setting has at the ½ manual power setting, which will decrease the flash duration by 1 stop. If the full manual flash fires normally in 1/1000 s, ½ manual flash will fire at a duration of 1/2000th of a second. Similarly, in the automatic flash exposure mode, if the flash unit has a flash exposure compensation capability, setting it to a −1 reduces the flash intensity to 1/2000th of a second, if it is used at 11′.

However, if full flash fires at 1/1000 of a second, and it is impossible to have more than full flash, how can a +1 flash exposure compensation setting work? The sensor eye cuts short the flash duration if the flash unit is used at distances less than the maximum auto flash range. Using the flash at 8′ will cut short the flash duration 1 stop less than full flash. This unused flash power is conserved by the flash and is the reason automatic flash has quicker recycle times than full manual flash. At 7′ from your subject, you would be able to use a +1 flash exposure compensation. This would, then, be the equivalent of full manual flash: a +1 flash intensity if at 7′.

If you are standing approximately 5.6′ from your subject in the automatic flash mode, the flash duration will be cut off the equivalent of 2 stops early. This unused power is what allows the flash to recycle faster than if you were standing at 11′. If you were photographing a gun lying in the snow at night, you should anticipate an exposure error from the flash sensor being "fooled" by the reflectivity of the snow. Snowy scenes "fool" the camera meter with nonflash photographs and cause underexposures. The same thing will happen with the flash in the automatic mode. The sensor eye will read the light reflecting from the snowy scene and cut off the flash early, resulting in an underexposure (dirty snow). The compensation necessary is the same with automatic flash as with the camera meter. Bracket toward +1½ to +2. You could actually set the flash exposure compensation dial/button to +2, because at 5.6′, the equivalent of 2 stops of light currently will be unused by the flash. For example, being 5.6′ from a snowy subject would cause the flash duration to be reduced to 1/4000th of a second. If you set the flash compensation dial to +1,

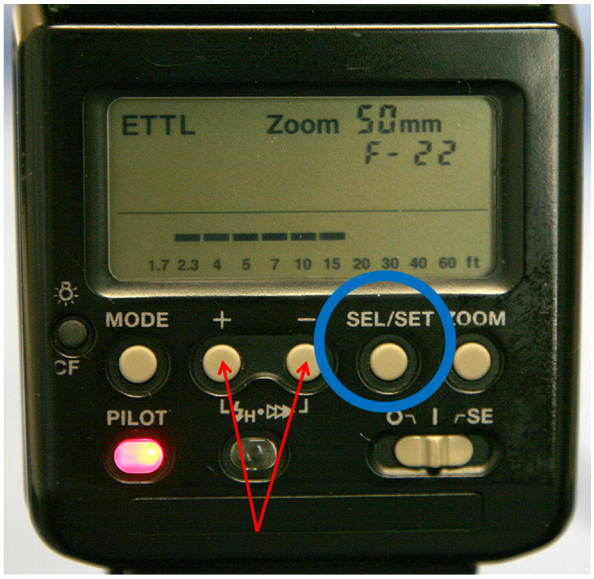


FIGURE 6.31
TTL exposure compensation selection method.

it would be changed to 1/2000th of a second; and if set to +2, it would be changed to 1/1000th of a second, the equivalent to full manual flash.

A brief recap of the automatic flash exposure mode might be helpful:

- Use an f/22 within the range of 2′ to 11′.
- Use an f/16 within a range from 11′ to 15′.
- Use an f/8 within a range from 15′ through 30′.

What, if any, are the negative aspects of automatic flash exposure mode? First, the sensor can be "fooled" by the reflectivity of very light-toned surfaces and very dark-toned surfaces. In these situations, flash exposure compensations will be required in the same way as exposure compensations were required when the camera body exposure meter was "fooled" in similar situations.

The flash head sensor eye is designed to provide the proper exposure when it is relatively close to the digital sensor. If the flash is removed from the camera's hot-shoe and used with a PC or remote shutter cord, it must still be aimed relatively directly toward the subject. The automatic flash sensor eye **cannot** provide good exposures when the flash is used obliquely to the subject.

Automatic flash exposure mode is a distinct improvement to the manual flash exposure mode. Is there another flash system that is even better?

Dedicated/TTL Flash Exposure Mode

With a dedicated flash unit, the camera and the flash unit are designed to work together closely; frequently, they are made by the same manufacturer. Rather than relying on a sensor eye on the front of the flash unit, a dedicated flash's light output is controlled by the light meter in the camera body. While the light from the flash is being projected, some light has already reached the scene, reflected off the scene, entered the camera **t**hrough **t**he **l**ens (TTL), and has been metered inside the camera body to determine a proper exposure. At times, this is expressed as a flash system relying on light being reflected into the camera and read by the camera meter after the light has bounced **o**ff **t**he **f**ilm (OTF). When this light level has been obtained (18%), the camera's light meter signals the flash unit, and the flash duration is cut off early.

This mode represents a vast improvement in exposure determination because the light is metered inside the camera body, next to the digital sensor where it is critical, rather than at the automatic flash's sensor eye. Many flash photographs are taken with the flash unit removed from the camera body, further distancing the automatic flash sensor eye from the digital sensor area. In these instances, a dedicated flash unit will always provide more accurate exposures than automatic flash units.

Dedicated flash units also work within various ranges, just like the automatic flash exposure mode. When a particular f/stop is selected, the flash range for that f/stop is shown on the LED of the flash.

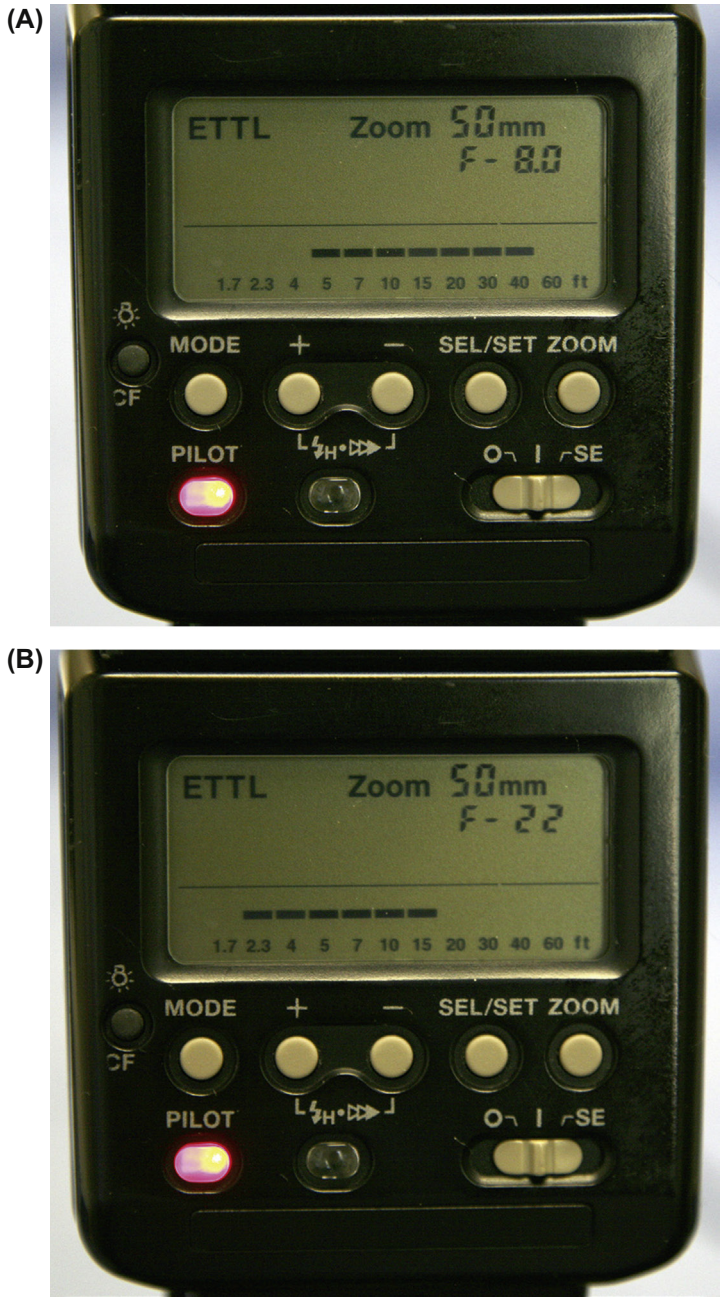


FIGURE 6.32
(A) TTL flash range for an f/8: 5′–40′. (B) TTL flash set for f/22: 2.3′–15′.

In the examples shown in Fig. 6.32, a dedicated flash is used with the camera set to f/8 and f/22, and the flash ranges for both are shown. You may notice the maximum flash range in each image is a bit longer than we have discussed. The f/8 is good up to 40′ and the f/22 is good up to 15′. A short test for the reader: what variables might cause longer flash ranges than expected?

- use of a faster ISO
- the focal length set to a short telephoto setting, which concentrates the light in a narrower beam which can then go further
- a flash with a higher GN

In this case, this particular flash had a GN of 160.

Fig. 6.33 shows the distances that a Nikon SB-900 Speedlight will light when set to TTL mode.

- f/8 covers 2.3′ to 37′.
- f/11 covers 2′ to 26′.
- f/16 covers 2′ to 18′.
- f/22 covers 2′ to 13′.

Dedicated Flash Exposure Modes have the same attributes as the automatic flash exposure mode:

- If used at the far end of the flash range, it is the equivalent of the manual flash light output.
- If used at closer distances within the indicated flash range, the flash will recycle more and more quickly.
- If used at closer distances within the indicated flash ranges, the life of the batteries will be significantly improved.
- If used within the indicated flash range, the same f/stop can be set once and not have to be reset at different distances.
- The exposure determination will be incorrect when photographing scenes with predominantly light-toned subjects or with predominantly dark-toned subjects.

However, the dedicated flash mode is not adversely affected if it is used **obliquely** to the subject, because the meter in the camera body will prolong or cut short the flash duration when it receives the correct amount of light. Being right next to the digital sensor is the ideal position in which to determine proper exposures for most "normal" situations.

Flash units featuring dedicated flash mode operation are the most expensive flash units. Many dedicated flash units still offer the option to switch to manual flash exposure mode when precise exposures need to be determined or when reflectivity issues may adversely affect the dedicated flash's ability to properly determine the correct exposure.



FIGURE 6.33
Flash distances for the Nikon SB-900 set to TTL flash mode.
Courtesy of Craig Wineman, Manager, Penn Camera, Fair Lakes, VA.

Dedicated flash units will invariably work with a flash exposure compensation dial/button that changes the flash durations. Many offer a flash exposure compensation from +3 through −3, sometimes in 1/3-stop or 1/2-stop increments. Of course, the + brackets are not really available if the flash is used at the farther end of the flash-to-subject working distance, which is the equivalent of the full manual flash output, and the dedicated flash output cannot be greater than the full manual flash output. It can always be less, but it can never be greater.

If a flash unit has all three flash exposure modes, using the dedicated flash exposure mode is recommended for most flash photography instances.

BUILT-IN FLASH UNITS

Many SLR cameras have built-in, pop-up flashes (see Fig. 6.34). This text will not spend much space addressing this type of flash, other than to point out some of the reasons they should not be relied on at most crimes scenes.

Perhaps foremost in their list of negative aspects is their low GNs. Many of them feature GNs around 35, indicating that at a 10′ distance an aperture of f/3.5 would be appropriate. Nowhere else in this text will you find a recommendation to use an f/3.5 as the optimal aperture for most crime scene work. The DOF would be horrible. If it is necessary to capture just one item of evidence at a relatively close distance, perhaps the built-in flash can be used for its sheer convenience. However, convenience is often a reason for doing something when no other reasons can be imagined. Using a stronger removable flash would result in smaller apertures, which are normally preferred.

Because subjects are so close to the lens, red-eye will almost always result when photographing people looking toward the camera.

Built-in flashes also emit light in a very direct line toward the subject. Direct flash is not an "attractive" type of light. It is not a flattering light for people, and it frequently produces harsh hot spots on many surfaces. Many other aspects of creative and professional photography do not apply to crime scene photography, but this aspect of built-in flashes also makes them an unpopular type of light. Going to the effort to remove the electronic flash from the camera with a PC or remote flash cord goes a long way toward reducing the negative aspects of direct flash.



FIGURE 6.34
Typical pop-up flash that some cameras feature.
Courtesy of Ron Taniwaki, Nikon Forensic Services.

FILL-IN FLASH

This text already introduced you to nonflash exposure concepts, and now the basics for determining proper exposures with a flash unit have been presented. Discussing **Fill-In Flash** incorporates both aspects: parts of the scene will be lit with relatively strong ambient light, and an electronic flash unit will supplement that light to provide lighting in areas currently in the shadows.

Recall the concept of exposure latitude and dynamic range. Sensors cannot record fine detail in both deep shadow areas and well-lit areas. In these situations, you can use the ambient lighting to properly expose those areas that are brightly lit and use the electronic flash to properly expose those areas that are dimly lit. The trick is to determine the proper balance between the two, so the scene does not look as if it were lit by two suns, or two flash units lighting the scene from two different directions.

The lighting recommendations for fill-in flash are borrowed from professional photographers who do portraiture photography. In a photographer's studio, the primary light is referred to as the key light, or main light, which is frequently a large light box or flash aimed into an umbrella. It is frequently raised up higher than the subject's face, and it is directed to light the subject from a high diagonal angle, which is the strongest light for a portraiture setup. Lighting one side of the subject's face, this key light naturally produces shadows on the opposite side of the subject's face. These shadow areas are normally too dark for an effective photograph. To throw some light into these areas, a photographer can use a secondary fill-in light. This can also be a light box or flash directed into an umbrella so that harsh light does not strike the subject's face. But, the fill-in light is intentionally set so that it is **not as bright** as the key light. The image would look strange if the subject's face was illuminated with equal light intensities from two different directions.

Photographers have experimented with many different key-fill light ratios to determine a pleasing effect, and one of the most frequently used ratios is 1:2. This means the key light is set as desired to light one side of the subject's face, and then the fill-in light is set to be exactly 1 stop less bright. The fill-in light is half as bright as the key light. This lighting situation produces a shadow on the side opposite from the key light, but details of the face can still be seen and recognized in the shadow area.

How is this ratio established? You must first determine just what intensity of light the bright parts of the scene are receiving, which is done by taking an exposure reading from the bright part of the scene. When this is done, it is important to meter **only** the bright area of the scene. Do not take a meter reading from an area of the scene that includes both the bright and dim areas of the scene.

For example, according to the f/16 sunny day rule, you would expect the sunlit area of a scene to require either an f/16 or f/22 for a proper exposure. An area in deep shade might need an f/5.6 or f/4 for a proper exposure. If you made the mistake of metering an area that was half sunlit and half dimly lit, the meter would do its best to average these lighting extremes. This average might result in a meter reading of f/9.5, halfway between f/22 and f/4. Actually, this f/9.5 would light neither area adequately. It would be 2½ stops too bright for the areas of the scene requiring an f/22, and it would be 2½ stops too dim for those areas of the scene requiring an f/4 for a proper exposure. The highlights will be overexposed, and the shadow areas will be unacceptably underexposed. Sensors do not have the exposure range to capture details under conditions that include both bright highlights and dark shadow areas.

Flash is strong enough to be the primary light source when required. In the fill-in flash situation, the flash is delegated to being just a supplement to the bright ambient light at the scene. It is normally recommended to balance the two light sources so that the light coming from the flash unit is 1 stop less bright than the bright ambient light in the scene. Having two different main lights, coming from two different directions, would produce a confusing result. It is more natural to have one of the light sources be considered as the key light and the other light source be delegated to be a fill-in light, adding just enough light to the shadow areas to provide for proper exposure there.

Fig. 6.35A has been exposed for the sunny part of the scene, and that area looks properly exposed, but the shady areas are too dark. Fig. 6.35B has been exposed for the shady areas, and those areas look properly exposed, but the sunny area is now overexposed. Fig. 6.35C was taken using fill-in flash. Both areas of the scene appear properly exposed. The knife in the shady area can easily be seen, but the shadows have not been obliterated with too much flash.

This is the fill-in flash sequence:

1. Because the scene is brightly lit, set the digital camera to ISO 100.
2. Meter the light in just the bright part of the scene. You must remember two things. First, take this meter reading with the camera set at the camera's sync shutter speed. After all, flash will eventually be used. Second, fill the frame with the sunny area of the scene when taking this meter reading. You are not interested in the meter reading of the scene half sunlit and half in shade. You want to set the camera exposure settings to properly expose

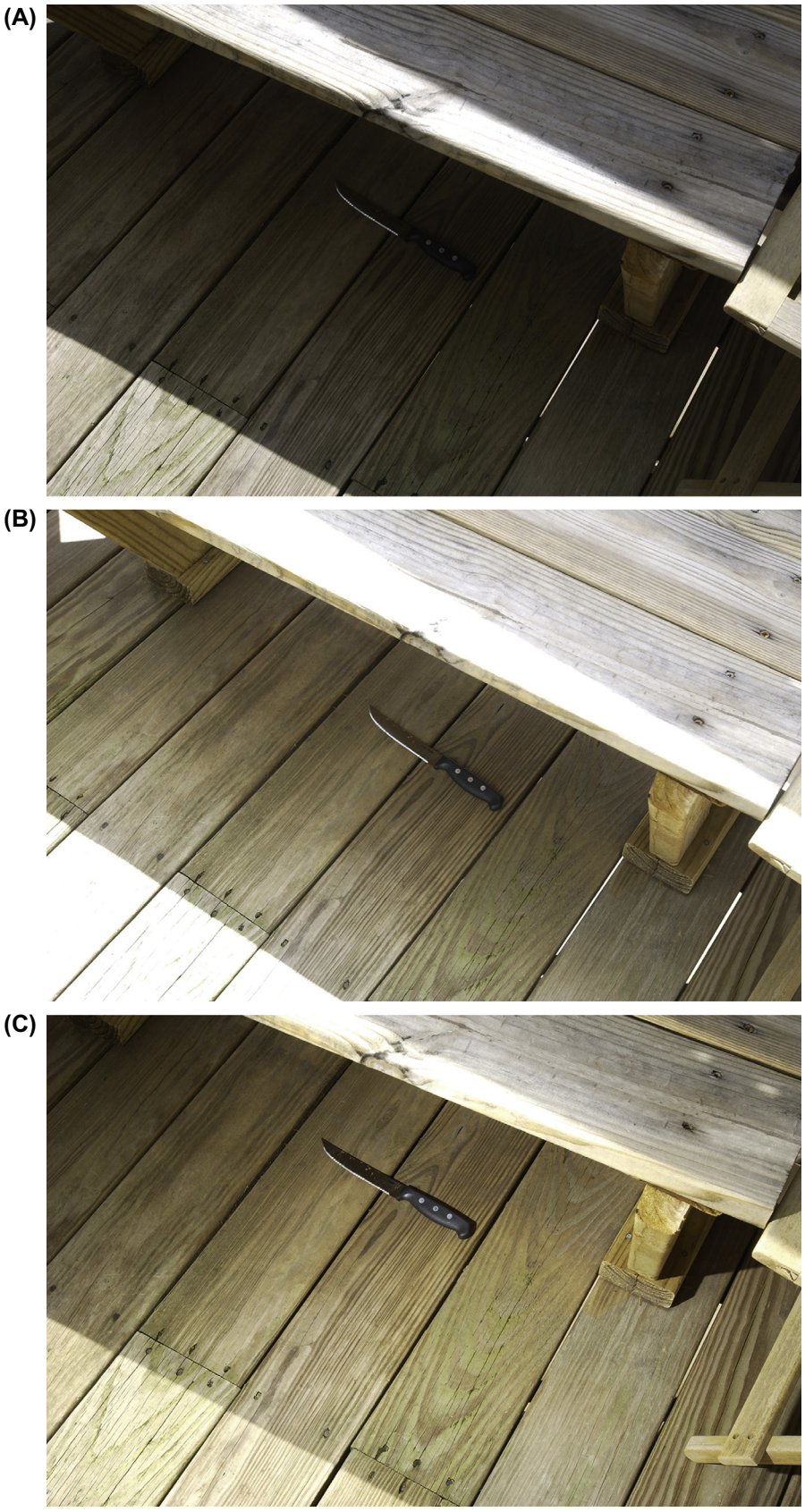


FIGURE 6.35
(A) Exposed for the sunny area. (B) Exposed for the shady area. (C) Exposed using fill-in flash: both areas look good.
Courtesy of Sarah Reeve, GWU MFS student.

for only the sunlit part of the scene. When selecting this sunlit area, use care to avoid certain subjects. Do not take a meter reading on sunlit vehicles within the scene. Glare from painted sheet metal would produce an erroneous meter reading. Also avoid extremely light-toned sunlit areas or extremely dark-toned sunlit areas. The best areas to meter would be sunlit green grassy areas or sunlit well-traveled asphalt. Even if these areas will not be in the composed part of the scene of interest, they will provide the proper starting point.

3. This meter reading will suggest an f/stop that corresponds to the sync shutter speed. Set the camera for this f/stop.
4. Set the flash unit to the manual flash mode. You do not want the Automatic flash's sensor eye or the dedicated flash's camera light meter to read glare or other overly bright lights at the scene and cut the flash duration off prematurely.
5. Now you need to position the flash unit and determine the ratio of flash lighting to ambient lighting. To determine the position for the flash unit, recall that the flash LED screen associates two variables: distances and f/stops. Because an f/stop recommendation has just been obtained from the meter reading of the sunlit part of the scene, notice what distance the flash LED panel indicates is appropriate for that f/stop. Using the flash LED panel, position the flash unit at this distance. That may mean you step in closer to the primary subject or take a step backward.
6. Next, realize that actually taking the photograph from this position is the equivalent of taking a full flash photograph. Or is it? Although you definitely want to set the flash so that it is 1 stop **less bright** than full flash, do you need to adjust the flash any further? Remember the concept of manual flash used in a "normal" room? If not in a "normal" room, the manual flash will be either brighter or dimmer. Outside, manual flash is already 1 stop dimmer because it is not receiving the extra light that white walls and a white ceiling would reflect back toward the subject. Therefore, the flash is now set to be 1 stop less bright than the sunlit areas of the scene.
7. Ensure the flash is aimed at the area of the scene where it is most needed. Sometimes having the flash unit mounted on the camera's hot-shoe, on top of the camera, is not the most appropriate place for it. Consider turning the camera upside-down so the flash is underneath the camera; or take the flash off the camera, connect it to the camera with a PC cord or remote flash cord, and aim the flash where it will do the most good.
8. Take the photograph.

When this is done properly, not only will the sunlit area of the scene be properly exposed, but the area in the deep shadows will also reveal details not otherwise seen. Although these details are visible, notice that the sunlit area is not overexposed. Both look well exposed.

Fig. 6.36A was exposed for the sunlit area of the scene. The sunny areas look well exposed, but the shady area is underexposed. Fig. 6.36B was exposed for the shady area of the scene. The knife is visible, but the sunlit areas are obviously overexposed. Fig. 6.36C has been exposed with fill-in flash. Both the sunlit areas and the shady areas of the scene look properly exposed. The knife is visible, but the shadow it is in has not been blasted by too much flash.

A backlit scene is also one with wide extremes of light in it. If a person is sitting near a window, and the scene outside is included in the field of view, the camera meter will overreact to the bright outside area in the background of the photograph and cause an underexposed subject. This will also occur if a person outside is facing you, and the sun or bright sky is behind him or her, as in Fig. 6.37A. If your composition will include a lot of the scene around your primary subject, and that area is brightly sunlit, the subject who is shade-lit will be underexposed if the camera's meter is set according to the sunlit area. The proper use of fill-in flash can ensure both areas of the scene are exposed adequately, as in the right image of Fig. 6.37B.

When the idea of fill-in flash is taught, because two very differently lit areas are within the same composition, it is usually pointed out that either part of the scene can be overexposed, properly exposed, or underexposed. To make sure students fully understand the ability to control the exposure level of either area separately, they are frequently required to arrange three photos so that the interior subject is properly exposed in all three, but the exterior should be overexposed in one photograph, properly exposed in another, and underexposed in the third. Then, the students are told to maintain a proper exposure for the exterior while underexposing the interior in one photograph and overexposing the interior in the final image.

It is usually pointed out that Hollywood frequently uses this capability to expose scenes differently for various effects. Look at some of the old-time "film noir" genre films. Those are gangster movies or other films in which it seems as though the entire film occurs in the night or under dark rainy conditions. The movie cinematographer used the dark, dreary lighting conditions to set the mood of the movie. At times, the filming of the movie continued after the sun began to rise, but to continue the same feel for the movie, the camera operators merely underexposed the sunlit scenes. If you look closely, when you catch a rerun of these films, people are running around nighttime street scenes, but strangely suspicious shadows are around them. A sunny day can be underexposed to simulate nighttime, but the shadows remain.

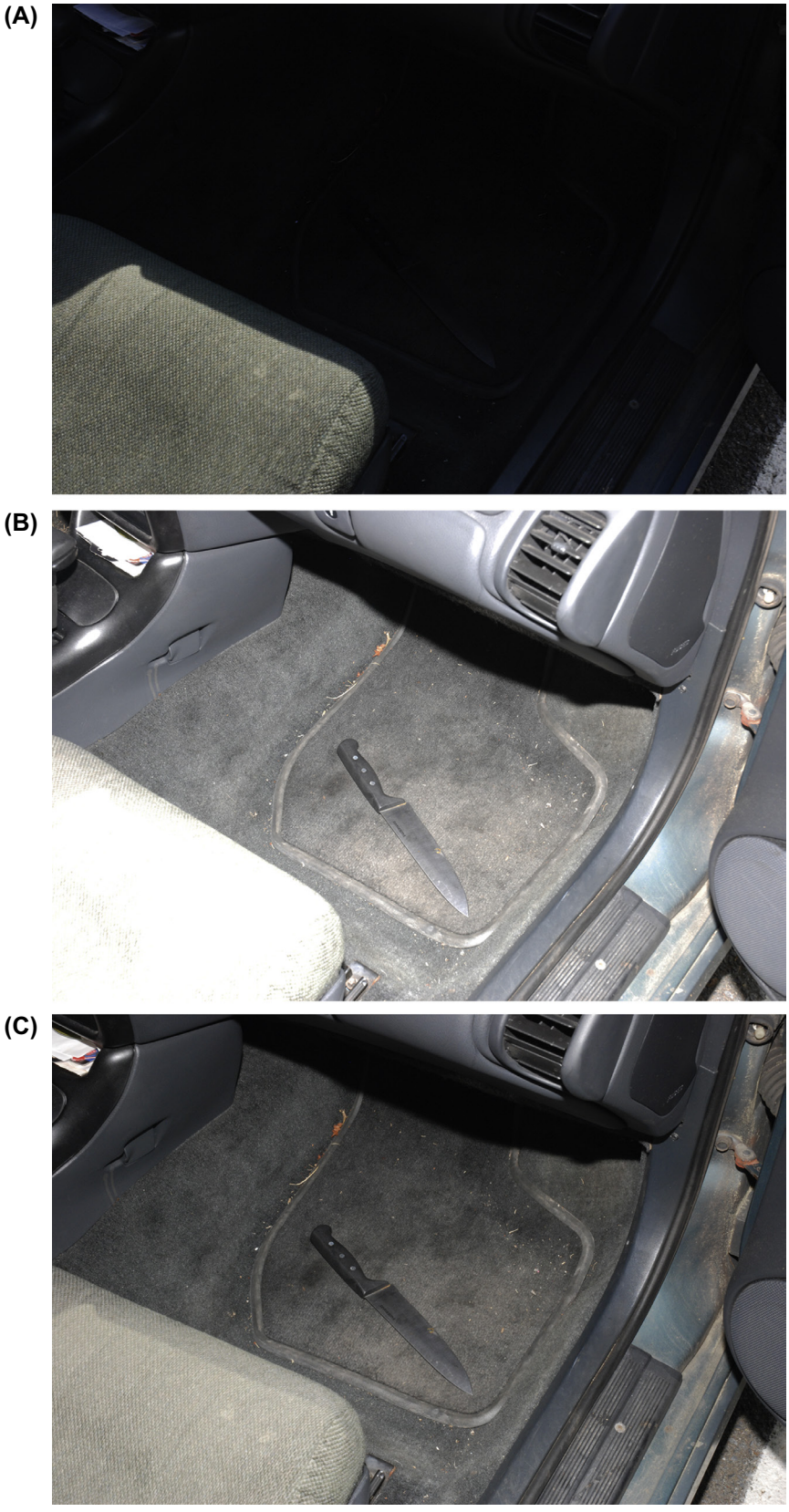


FIGURE 6.36
(A) Exposed for the sunny areas. (B) Exposed for the shady areas. (C) Exposed using fill-in flash: both areas look good.
Courtesy of Derek Foote, GWU MFS student.

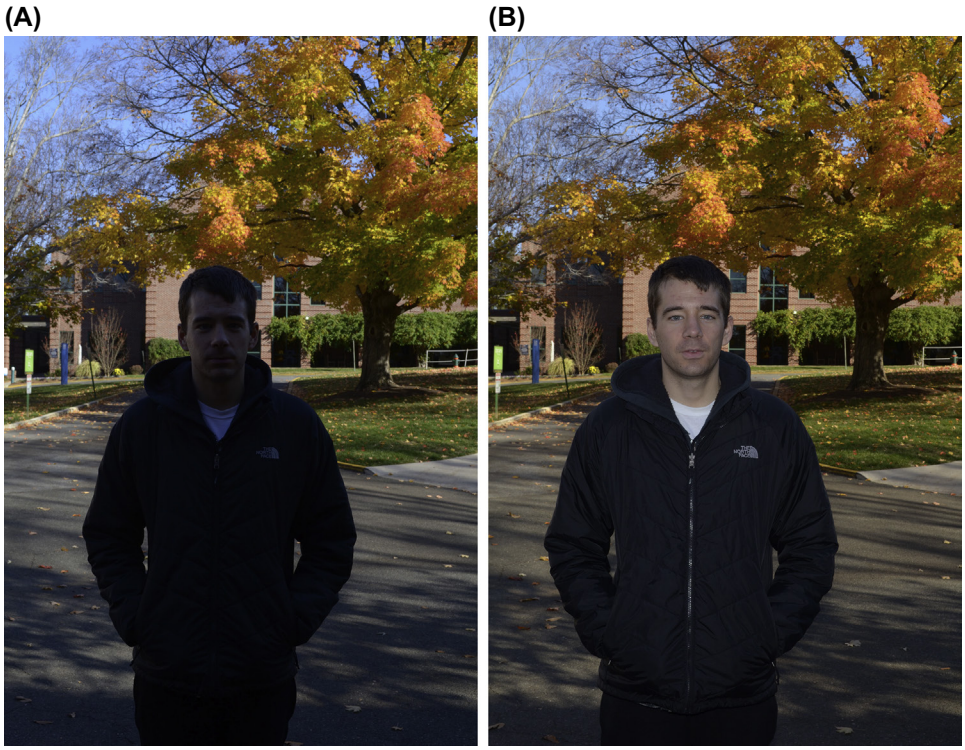


FIGURE 6.37
(A) Exposed for the background. (B) Fill-in flash.
Courtesy of L. Pacheco, GWU MFS student.

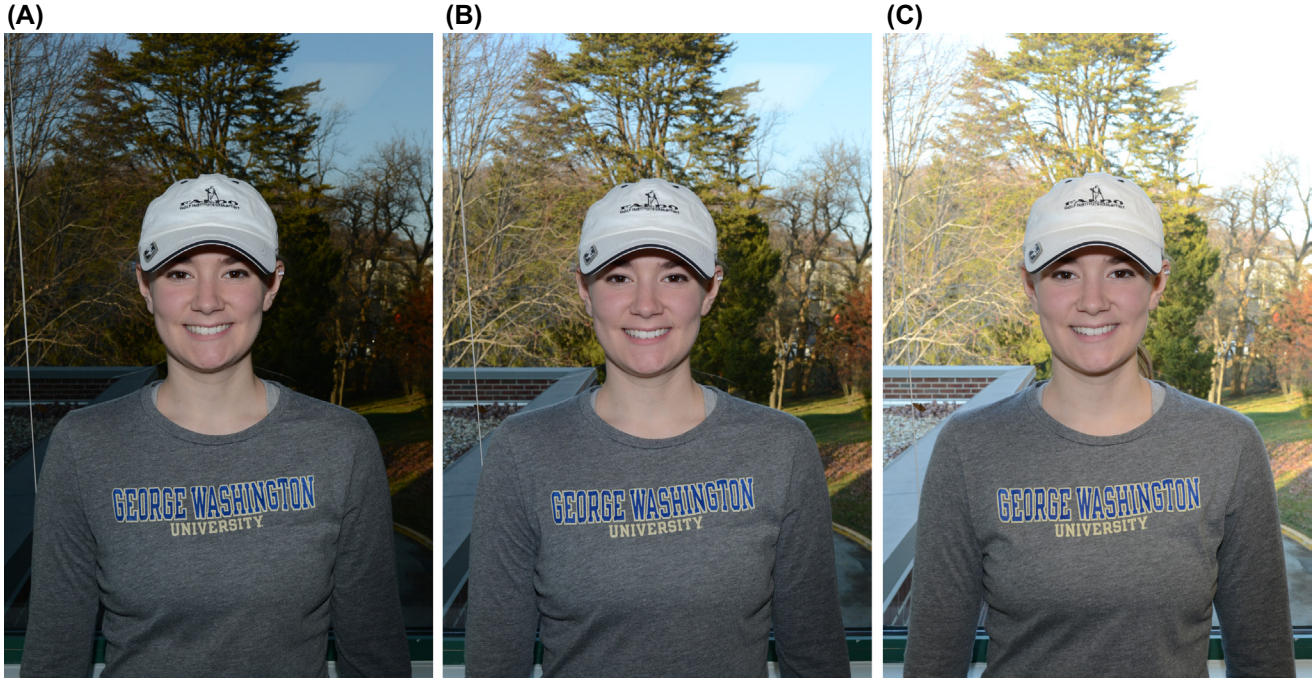


FIGURE 6.38
(A) Exterior intentionally underexposed. (B) Exterior properly exposed. (C) Exterior intentionally overexposed.
Courtesy of D. Maslanka, GWU MS student.

The sequence of images in Fig. 6.38 demonstrates the ability to separately expose two parts of the same scene. The challenge, in this case, was to determine three different exposures for the background: one underexposed, one properly exposed, and one overexposed. Then, the challenge also called for the girl in the George Washington University (GWU) shirt to be properly exposed by the fill-in flash in each shot. A different challenge could have been for the

background to be properly exposed in each shot, but the subject nearer the camera could have been overexposed, properly exposed, and underexposed. This effect does not usually happen without your knowing and using the fill-in flash technique correctly. Again, when properly done, fill-in flash ensures that both parts of the scene are properly exposed—both the area that had been sunlit and the area that was backlit.

It is fair to ask which flash exposure mode is best suited for fill-in flash. Although some very expensive flash units offer automatic fill-in flash settings, this author believes the manual flash exposure mode is most appropriate for fill-in flash. This technique is used when bright parts of the scene are present. The automatic flash mode and the dedicated flash mode offer the possibility of reducing the flash duration when bright light affects the flash sensor or the light meter in the camera body. If the flash durations should be altered, the 1:2 key/fill flash ratio may be altered, and that is not desirable. Only the manual flash exposure mode gives you complete control of this lighting condition.

Whenever lighting conditions include bright sunlit areas and dark shadows, the use of fill-in flash should be considered. If the sun is producing noticeable shadows, the use of fill-in flash will benefit most photographs.

OBLIQUE LIGHT, BOTH FLASH AND NONFLASH (FLASHLIGHT)

Many times, lighting the 3-D textures and patterns of evidence is necessary. Tire tracks, shoe prints in dirt, bite marks, fingerprints in window putty, indented writing, and dusty shoe prints are just some examples of the range of 3-D impressions crime scene photographers may encounter. Some may consider dusty shoe prints to be an example of a two-dimensional pattern, although they are actually a physical medium sitting on the surface of another medium.

To successfully photograph these types of evidence, you often need some form of side lighting or oblique lighting. Electronic flash is usually the light of choice, although a good flashlight can perform well in certain situations. Despite the fact this is a chapter on flash techniques, when a flashlight can do as good or better, that fact will be pointed out.

Direct Light Versus Oblique Light

When 3-D evidence has to be photographed, directly lighting the evidence is actually counterproductive to producing the best photograph possible. When a 3-D type of evidence, such as a shoe print in dirt, is directly lit, the light from the flash gets into all the nooks and crannies of the imprint and actually washes out some of the 3-D aspects of pattern and depth.

Fig. 6.39A shows a shoe print in dirt lit by direct flash. It is very difficult to see the impression because the flash effectively washed out the detail within the impression. Fig. 6.39B shows the same impression lit by **oblique flash.** The

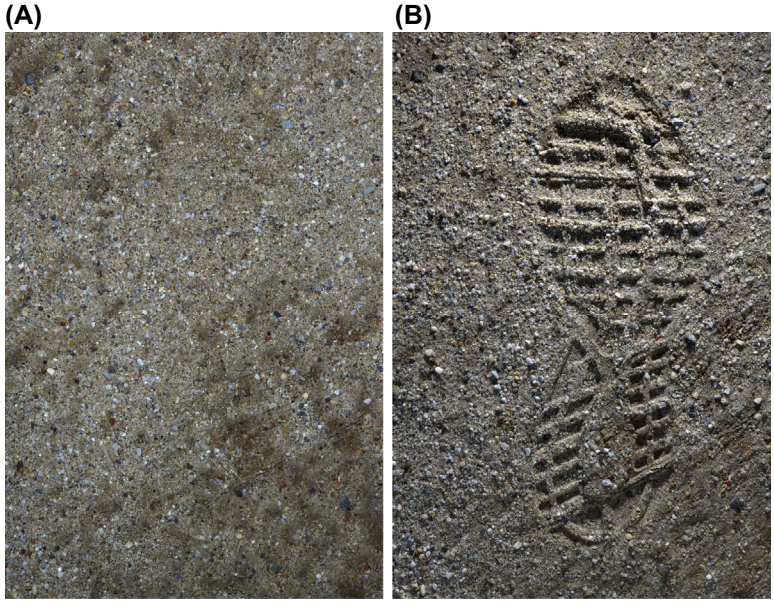


FIGURE 6.39
(A) Shoe print with direct flash. (B) Shoe print with oblique flash.
Courtesy of S. Keppel, GWU MFS student.

side lighting creates shadows, which makes it easier to see the 3-D aspects of the pattern. Depth and texture are evident now. Oblique lighting is absolutely necessary to show the detail of the shoe pattern.

Side lighting, or oblique lighting, provides the shadows necessary to better visualize 3-D aspects of evidence. However, the shadows produced by an oblique flash are also very dark. Details within this shadow area may not be visible. The contrast between the brightly lit areas and the shadow areas may be too extreme for a digital sensor. This was explained in reference to fill-in flash. These very dark shadows are called **Hard Shadows.**

Details within hard shadows cannot be seen. You are now faced with a paradox. If oblique flash is not used to light 3-D shoe print details, all detail may become washed out. If oblique flash is used to light a shoe print, your own lighting technique may be the cause of important details being lost within the "hard" shadows produced. Is there a solution to this problem? Yes.

The shadows produced by oblique flash have both good and bad effects. How can you retain the good effects and eliminate the bad effects? The use of a reflector solves the problem. When a reflector is used with oblique flash, the light from the flash strikes the impression and continues past it until the light strikes the reflector. The light then bounces back toward the impression, lighting the areas previously covered by "hard" shadows. The reflected light is not strong enough to wash out the shadows, but it is strong enough to light details within the shadow area. Shadows are called **Soft Shadows** when details within them can be seen.

Hard shadows hide detail; soft shadows reveal detail.

To teach this in a classroom, an old shoe is photographed on the floor. Fig. 6.40A shows the effect of an oblique flash producing a hard shadow on the opposite side of the shoe. The carpeting within the hard shadow area is also impossible to see. Having a shadow obscure areas around the evidence may seem trivial, however. But shadows are also produced within the shoe print. If part of the shoe print is hidden from view by the flash technique, it is time to alter the flash technique.

Fig. 6.40B shows the result of the use of a reflector to correct the hard shadow effect. Light has bounced off the reflector and has lit the areas previously within the hard shadows. The carpeting beyond the shoe is now visible because it is now in a soft shadow. The shadowing has not been eliminated. It is now, however, possible to see details within the shadow area. Again, lighting an area around the shoe does not seem that important. If shadows within the shoe print have also been lightened, that would be important. The shoe was altered to demonstrate the importance of bouncing light into the shadows within the shoe print. That is where shoe print examiners need to be able to see nicks, cuts, gouges, and embedded rocks. To make this point, a name was printed three times inside the shoe tread.

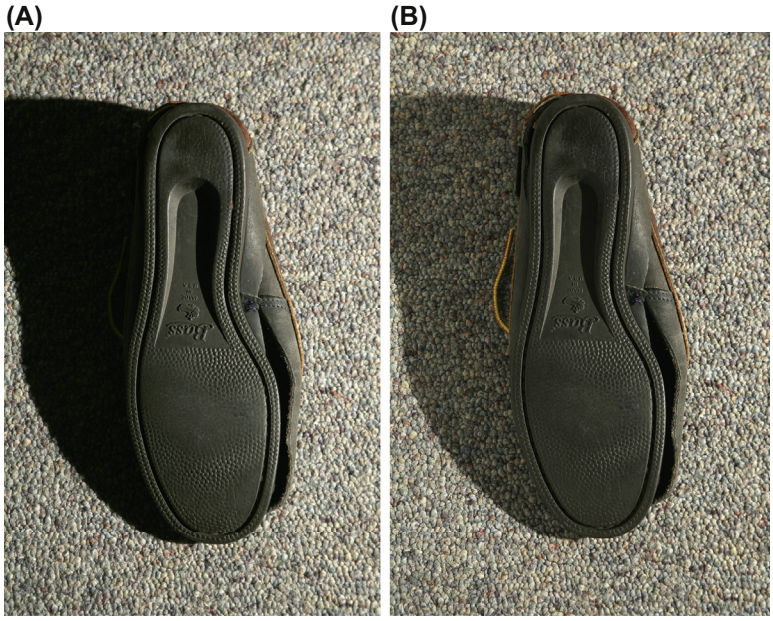


FIGURE 6.40
(A) Shoe with a hard shadow. (B) Shoe with soft shadow.

Fig. 6.41A shows all three "TEDs" lit with direct light. The name was put on three different vertical surfaces so that light coming from various sides of the shoe would tend to hide one or the other in a hard shadow. Fig. 6.41B shows the hard shadow in a close-up of the shoe lit by oblique flash with no reflector. One of the "TEDs" is now hidden within the shadow. Consider the name to be an identifying nick, cut, gouge, or embedded rock. Hidden evidence cannot be used by anyone for identification purposes.

In these situations, it is critical to ensure a reflector is used to be able to "soften" the shadows, so details can be seen within the shadow area. Fig. 6.41C shows the same area with a reflector used to bounce light back into the shadow areas. Within a soft shadow, the third "TED" is now visible.

What kind of reflector was used to create this effect? Reflectors can be as simple as a single sheet of report form paper. Crime scene photographers always have these handy. However, this requires one or two hands to hold it so it reflects light back into the impression, and frequently you are doing this kind of photography without help. You usually are busy holding the flash off-camera on a PC or remote flash cord and do not have extra hands available. At times, simply folding the paper so it would stand on its own is all that is needed. This has worked numerous times. But the slightest breeze defeats this plan.

Pictured here is a homemade reflector that effectively bounced the light where it was needed without anyone having to hold it. Fig. 6.42 shows this reflector. It is not patented, and this author hereby gives all readers of this book permission to copy it. The back is tilted down a bit to facilitate the light bouncing into the impression rather than missing the impression. A little tape, cardboard, and white paper, and you will be set. You will be the envy of your entire agency.

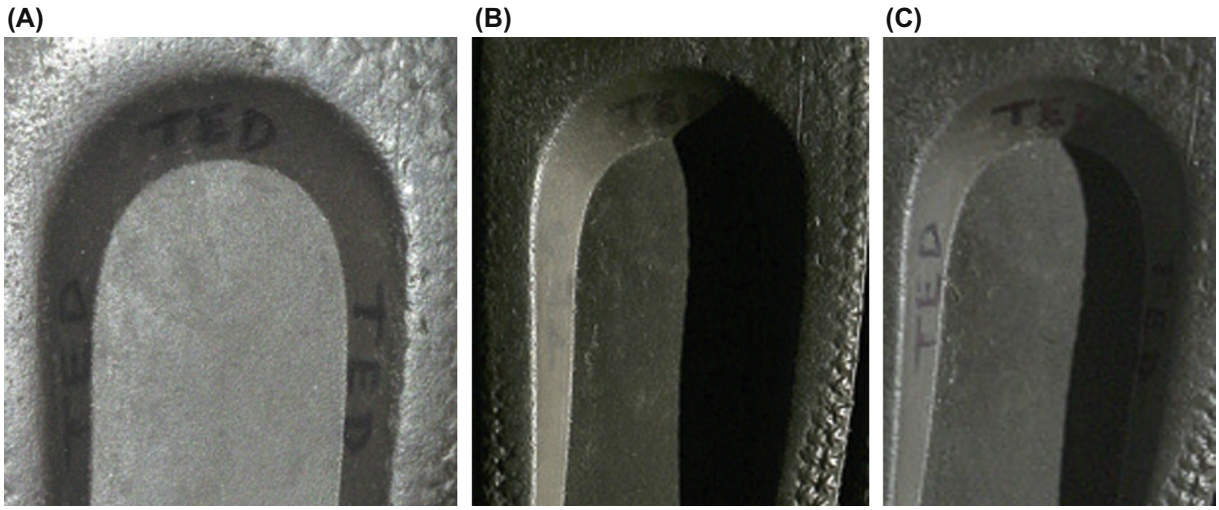


FIGURE 6.41
(A) Three TEDs. (B) Shoe with a hard shadow. (C) "TEDs" with a soft shadow.

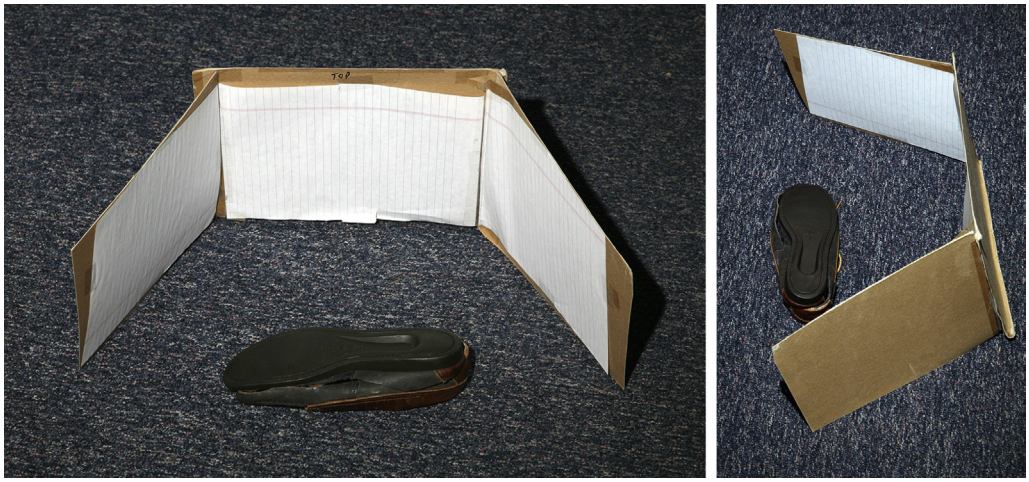


FIGURE 6.42
Homemade reflector.

The Oblique Flash Sequence

At what angle should the flash be held? This angle is best determined by viewing the imprint from directly overhead while you move a flashlight through various angles, watching as different shadows are created with the different flashlight positions. This will vary with the depth of the imprint, so this procedure will always have to be performed to determine that the optimal shadowing has been obtained.

From how many locations around the impression should the flash be aimed at the impression? Because the camera is always mounted on a tripod so the film plane can be positioned parallel to the impression, the best answer is to fire a **series** of flashes between each of the three tripod legs. The **series** is, of course, a set of three brackets: a 0, +1, and −1 from three different angles. Not that crime scene photographers do not trust their ability to determine the proper exposure for this situation, they take these bracketed shots so that the shoe print examiner has a wealth of options from which to choose. All nine of these images have a scale placed alongside the impression; **not** just alongside the impression, it is placed **on the same plane** as the depth of the impression. If the shoe print is ½″ deep in the dirt, a depression alongside the impression that is ½″ deep needs to be dug so the scale is at the same distance from the digital sensor as is the bottom of the impression. Only in that location can the scale enable a life-sized print to be made.

Before those nine photographs are taken, one image should be taken **without the scale** in view. It is always wise to take at least one image before you have added anything to a scene. Defense attorneys may ask what has been hidden by the scale and if the original scene was conveniently found with the scale already in it. Since a flash is used for all 10 of these images, ensure that you also use a reflector for all 10 images.

Whenever the camera is on a tripod, the shutter button should not be manually depressed. Doing so may generate some camera movement and can result in blur. Use a shutter release cable or a delayed shutter setting. Many cameras now offer the photographer a 2-s delay or a 10-s delay. This brief time delay allows the camera to settle down after the shutter has been pressed to avoid camera shake and blur.

Earlier it was mentioned that three series of brackets should be taken from three different positions. You may ask what the beginning exposure is. Determining this is not as simple as it sounds. Of course, because this is an example of a critical comparison photograph, also called an examination quality photograph, the ISO that is recommended is ISO 100. Because a flash will be used to light the imprint, it makes sense to use the sync shutter speed.

This author believes that the f/stop that is best for critical comparisons is f/11. The f/11 is chosen to avoid the loss of resolution due to diffraction. However, as previously mentioned, the OSAC Footwear and Tire Subcommittee are in the process of determining their own recommendations for capturing examination quality digital images of 3-D patterned evidence. Ultimately, their recommendations may become mandates. It remains to be seen what they will decide. As the 2013 SWGIT Guidelines for Photographing Footwear and Tire Impressions previously indicated, to optimize DOF in these circumstances was to select an aperture, "generally two stops below the largest f-stop or smallest aperture opening." It is hoped the OSACs continue this recommendation.

But, would f/11 provide a proper exposure in this particular situation? If a dedicated flash unit were used, then the light meter in the camera body would ensure a flash duration proper for all the other variables. That would really simplify things. If you do not have a dedicated flash, is automatic flash or manual flash the better flash mode to use? The automatic flash exposure mode is not really an option. Having the flash sensor eye so far away from the digital sensor makes no sense. With the manual flash mode, how is the f/stop to be determined? Remember that the manual flash LED distance/f/stop recommendation applies only to direct flash, not oblique flash.

The only way to determine whether the f/11, normally suggested for critical comparisons, provides a proper exposure for oblique flash situations is to do a series of test exposures. Fortunately, these have already been done for you, under the two extremes this technique will have to be used: at midnight and noon.

At midnight, with the only light available being a single flash unit, a shoe print was placed in dark dirt, and it was photographed at every f/stop between f/2 and f/22. The flash used had a GN of 120, so you will have to modify this recommendation if your flash unit is different. Fig. 6.43 contains some of those images.

You are in luck. The f/11 not only is a good aperture for critical comparisons, but also happens to be the f/stop that provides the best exposure of all the f/stops when photographing shoe prints in dirt at midnight.

Brackets are also recommended. How? The +1 bracket is achieved simply by changing the aperture to f/8. That is also appropriate for critical comparisons. It is not, however, recommended to change the aperture to f/16 for the −1

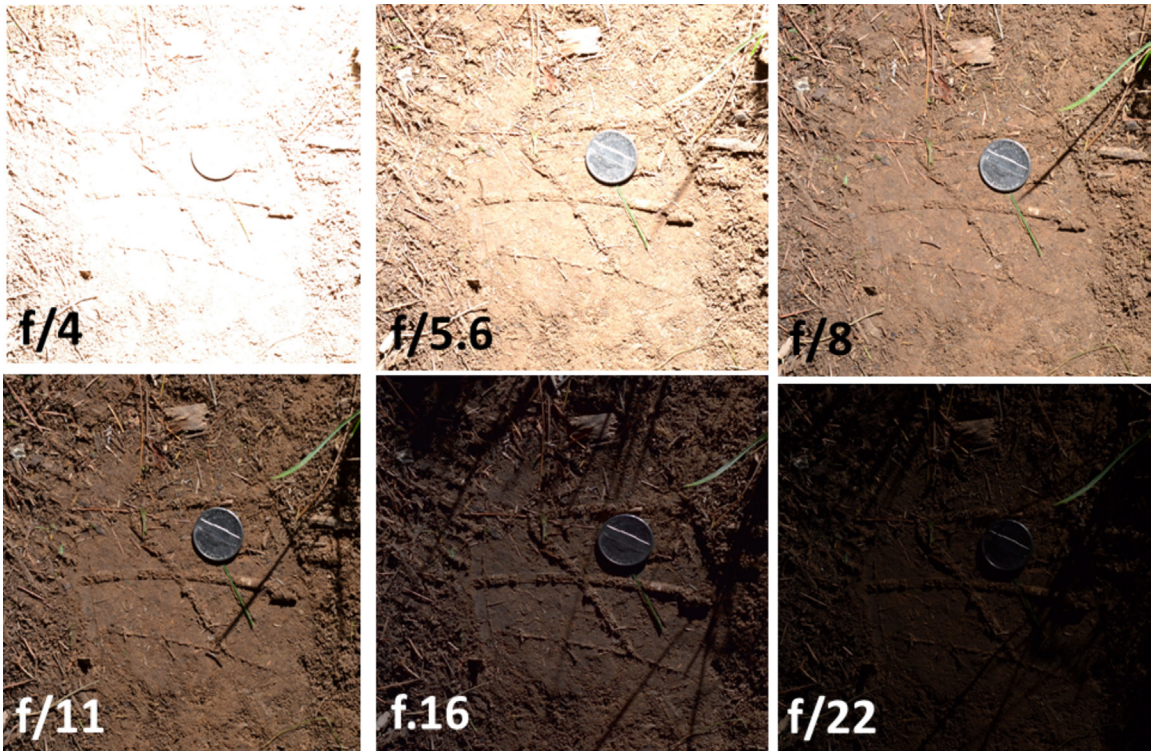


FIGURE 6.43
Shoe print in dirt with various f/stops.
Courtesy of GWU MFS student S. Lingsch.

bracket. The f/16 may show negative effects from diffraction. Instead, change the flash to f/11 at ½ power, or place one layer of handkerchief over the flash head. Either of those would be an acceptable –1 bracket.

Taking photographs of a shoe print in dirt at noon is the other end of the lighting spectrum. Initially, you would think that the additional ambient light would make this photographic situation problematic. Not so. At midnight, the initial exposure combination was ISO 100 film, sync shutter speed, and f/11. What is to prevent this combination from being used at noon? The only fear is that, at noon, with its bright ambient light, this same exposure combination may lead to a gross overexposure. So, we should think of ways to ensure the use of the f/11 does not lead to overexposure. Can the f/16 sunny day rule help us find a solution? A brief restatement:

- Initially set the camera at f/16 with bright light producing well-defined shadows.
- Initially set the camera at f/11 with light producing soft-edged shadows.
- Initially set the camera at f/8 for overcast days without any shadows.
- Initially set the camera at f/5.6 when in an "open" shadow but with blue sky above.

It would seem that all you would have to do is get the shoe print in dirt out of direct sunlight, and then an f/11 would not overexpose the impression. Why did we just say f/11 when the above clearly shows an f/8 recommended for an overcast day where the sun is not directly striking the impression? The f/8 is just a starting point, which also suggests the shutter speed corresponds to the ISO selected. At noon, with the sun out, an ISO of 100 is usually recommended, and the f/16 sunny day rule indicates the ISO be made a fraction, and the closest shutter speed to that should be used. 1/100 is closest to the shutter speed of 1/125. And, by reciprocity, the combination of f/8 and 1/125 can be changed to f/11 and 1/60 for the same exposure with a better DOF.

This works not only in theory, but in practice as well. All that is necessary is to ensure that sunlight does not directly strike the impression, which can be done simply by blocking the sun with your body, or have anyone present assist by blocking the sun with his or her body. When this is done, the flash then becomes the primary light, and all the other photographic variables as were used with the shoe print at midnight apply. Except at noon, the use of a reflector may not be needed. Light from the sky above may be all that is required to make all the "hard" shadows turn into "soft" shadows. But, when in doubt, use a reflector.

Before leaving the topic of photographing shoe prints in dirt, we should discuss one other issue. How long should the PC or remote shutter cord be? Most PC cords are about 3′ long. A couple of sources, including William J. Bodziak, author of the well-known *Footwear Impression Evidence* text, have recommended that the flash should be held 5′ to 6′ from the shoe print. Why is this? Mr. Bodziak explained that having the flash farther from the shoe print produces a more even lighting situation. The closer the flash is to the impression, the more the lighting will vary from the toe to the heel. This does make sense. According to the ISL, a 1-stop difference is between 1.4′ and 2′. Another 1-stop difference exists between 2′ and 2.8′, between 2.8′ and 4′, and between 4′ and 5.6′. That means if the shoe print was 12″ long, and the flash were 3′ from the impression, the side of the impression closest to the flash can be more than 1 stop brighter than the part farthest from the flash. This can make it harder for the examiner to see details within the impression. Removing the flash a bit farther reduces the flash intensity difference between toe and heel. With the flash 5′ to 6′ from the impression, the difference in light intensity from toe to heel is much less problematic for the examiner.

To get to this 5′ to 6′ distance, you can actually connect some PC or remote flash cords to form one longer cord. If your cords cannot be connected, another way to mitigate the flash intensity between toe and heel is to simply avoid aligning the flash so it must travel from toe to heel.

Fig. 6.44 shows the tripod setup when the tripod does not have a reversible center stem. The camera is above the impression, which runs parallel to an imaginary line connecting the two front legs, which are upright so the camera can be positioned over the impression and not have the tripod legs in view. However, this position has the camera able to be pulled forward when the flash is held to the left side of this image on a remote flash cord. To better balance the tripod, the back leg is counter-weighted with the camera bag, as seen in Fig. 6.44A. Fig. 6.45 shows the camera and tripod setup when the center stem is reversible. The impression is again lined up parallel to an imaginary line connecting the two front legs. Fig. 6.44A shows the three flash positions with the tripod setup either way. One flash will come from the front, aimed to strike the impression from the side, the narrowest distance across the impression, rather than from toe to heel, the farthest distance from one end to the other. The other two flash angles strike the impression from diagonals. These angles are also shorter than the full toe-to-heel distance. Until your agency supplies its crime scene photographers with 5′ remote flash cords, this setup may lessen the adverse impact of different light intensities over different distances.

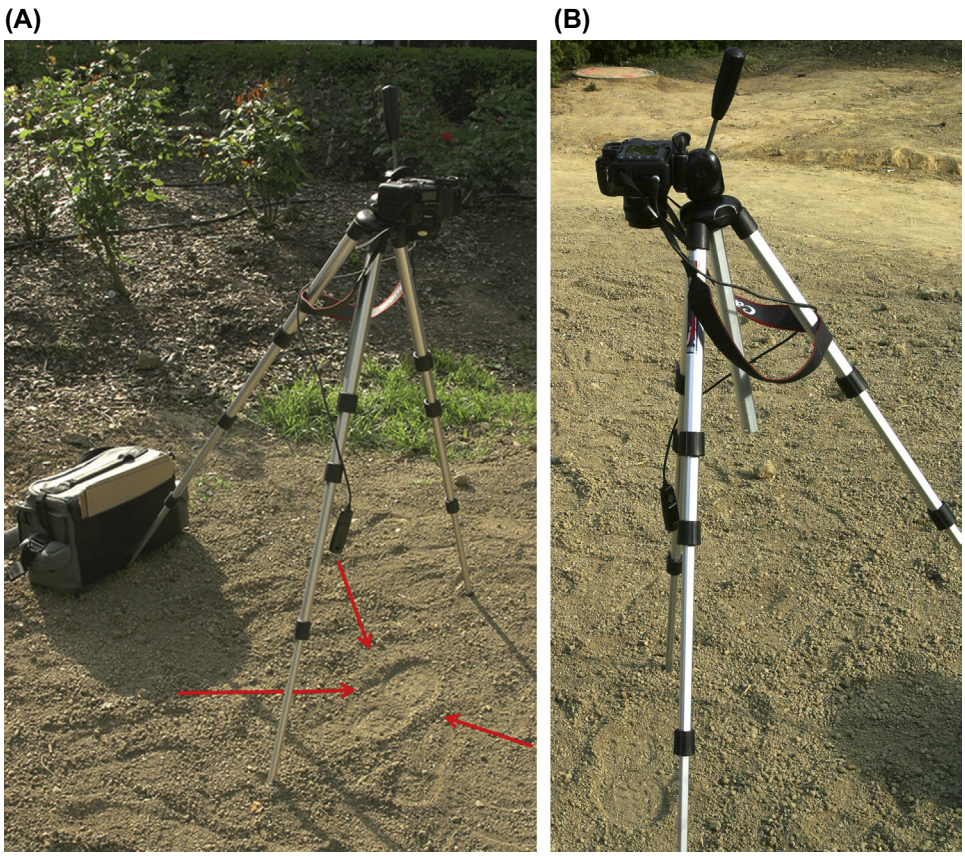


FIGURE 6.44
(A) Flash directions indicated with arrows. (B) Tripod position: center stem not reversed.



FIGURE 6.45
Tripod position: reversible center stem.
Courtesy of GWU MFS student J. Sinex.

Shoe Prints in Snow and Sand

The first thing which needs to be said about photographing shoe prints in snow is that you have to find them before you can photograph them. Obvious, right? I think we have taken it for granted that shoe prints at crime scenes will normally look like either of the images of Fig. 6.46. There will be some detail that can be seen, or continued snowfall has filled in the impressions to the point all detail is lost. This author actually remembers putting on a 3-D impression photography and casting demonstration at a local police academy, and casually mentioning that once the snow has filled a shoe print impression, like in Fig. 6.46B, there is nothing that can be done because we do not have any tools to recover impressions filled in with snow. Actually, this author is embarrassed to say those comments were repeated more than once at more than one training academy.

Two winters back, in the early morning, this author saw both of these shoe prints and photographed them. Then, for some reason, an article written by Tom Adair on impressions in snow came to mind. One point he made was that there were many types of snow, and knowing these differences helped one to recover impressions in snow. So, if all that were initially found at a crime scene were impressions like Fig. 6.46B, how could evidence still be found? For some reason, I got a broom and began sweeping the snow off the front sidewalk. The images in Fig. 6.47 is the result.

Shoe prints like those in Fig. 6.46 had been put on the snow after it had already snowed for some time. But, before that, when it had just begun to snow, it might have been warmer, and when the snow fell it may have been a very wet snow, resulting in a kind of slush on the sidewalk. Then if the temperature began dropping, and someone may have walked through the slush just before it froze. The frozen shoe prints were then covered by a very powdery snow, leaving behind the surface which produced images as in Fig. 6.47. Sweeping off the powdery snow revealed the frozen shoe prints beneath it, just waiting for someone to find them!

You have to find them before you can photograph and cast them! Of course, one must process the visible impressions first, unless information already available indicates the currently visible impression were not made at the time of the crime.



FIGURE 6.46
(A) Shoe print in snow on sidewalk. (B) Another shoe print in snow on sidewalk, filled in with snow.

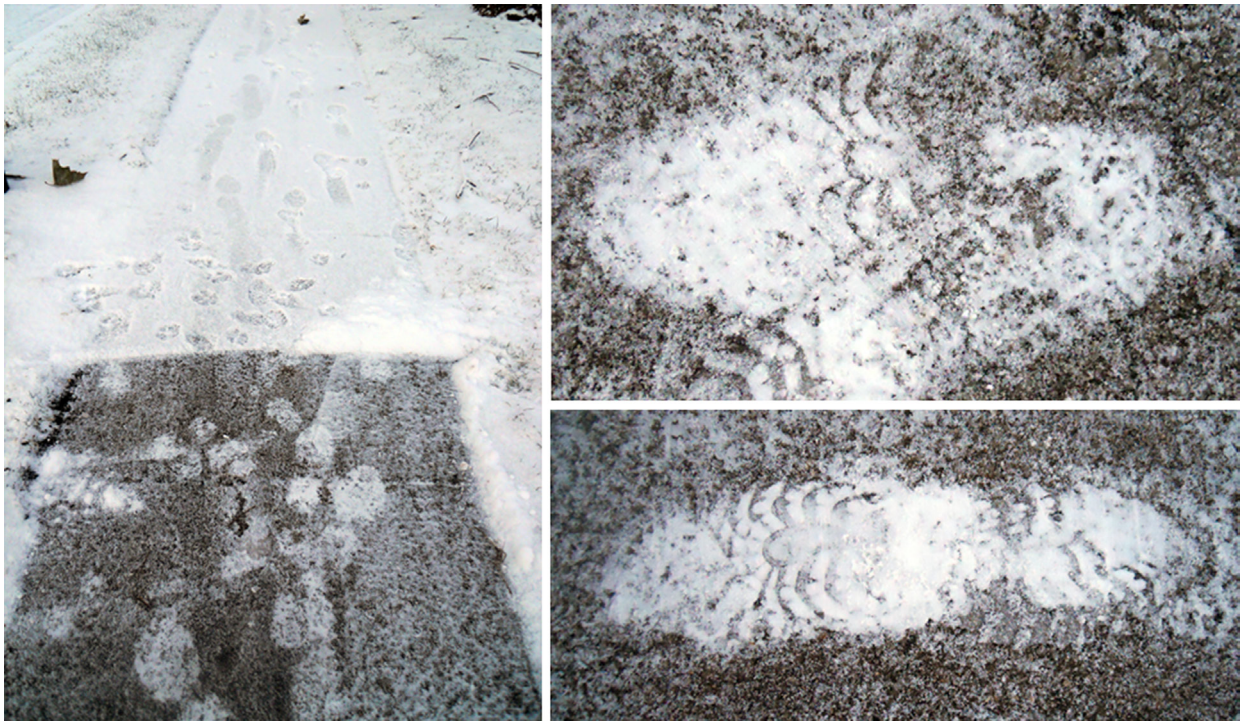


FIGURE 6.47
After sweeping some snow away.



FIGURE 6.48
Snow print wax on "snowy" shoe print.

Photographing shoe prints in snow adds some interesting complications to the normal photography of shoe prints in dirt. To begin with, snow can sometimes be on the verge of melting, as we have seen, making it imperative that the photography be done quickly and accurately the first time because there may not be anything remaining after a short time span. Fig. 6.48 shows the results of a practical exercise for students in a basic crime scene photography course regularly taught at a police academy. It was during the summer, so we simulated snow by crushing ice in a blender. The room temperature immediately began melting the slush we had created, so we doubted we would be able to document any worthwhile detail. We captured three quick photographs of the slush before treatment with **Snow Print Wax**, then sprayed the impression with the wax, and took two more photographs before everything melted away.

Snow print wax is used with shoe and tire tracks in snow because it provides contrast; the white subject matter makes it difficult to see pattern and details within the imprints. We were pleasantly surprised to notice the snow print wax almost visualized the brand name, "Spalding," before the slush completely melted away.

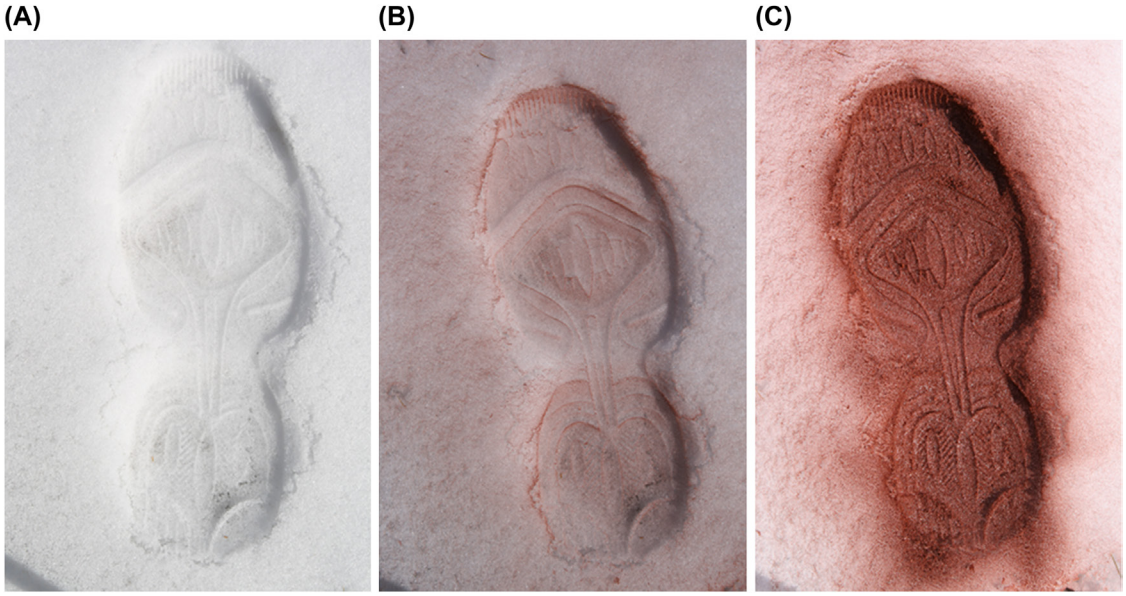


FIGURE 6.49
Shoe in snow, combo I.
Courtesy of GWU MFS student M. Towers.

The snow itself, as white evidence, has its own exposure issues. If either the automatic or dedicated flash modes are used, their sensors will read the excessive reflected light and tend to underexpose the images. This, in itself, would not be too bad because such white-on-white subjects are very hard to see with any details visible. A little underexposure may even benefit the photographs. Because the actual amount of underexposure may vary, many opt for the manual flash exposure mode when photographing snowy impressions.

Oblique flash normally produces shadows that make the 3-D texture and pattern easier to see. With snow, light will bounce around each of the vertical surfaces and tend to wash out the shadows needed to visualize fine details.

For these reasons, the normal "as is" photographs are not expected to be very useful, although they will still be done. Because of this white-on-white contrast problem, the next thing usually done is to add color to the snow prints to increase contrast so that more details can be seen. The color itself is unimportant. It is just necessary to diminish the white-on-white look of the original impression. Some have used a variety of spray paints, and some have even twirled a fiberglass filament fingerprint brush, loaded with black powder, over the impression. Both of these ideas will produce a better result than the original photographs. If, however, snow print wax is available, some feel this is the optimal material to use. It provides a good contrast with its red wax for the next round of photography. It also helps prepare the shoe print for casting, by covering the shoe print with a waxy barrier that helps prevent the melting of the snow when the castone begins to warm with its exothermic chemical reaction.

Spraying the snow print wax over the impression should be a two-step process. It is recommended to begin with a spray from just one direction. Spraying the impression from just one direction darkens some of the impression and leaves other areas without snow print wax. The effect is very close to the shadowing produced by oblique flash. Fig. 6.49B shows this effect. Although fine details may not be seen with this procedure, it certainly shows gross pattern very well. Another sequence of photographs is captured after spraying the shoe print with snow print wax from one side.

After these photographs are taken, the impressions should be sprayed with snow print wax from all sides so that all vertical surfaces within the impression are covered with wax. This can be done while walking around the impression and spraying into the impression. Although the wax can now be quite thick and may be masking fine details within the impression, the final round of photographs should now be taken, as in Fig. 6.49C.



FIGURE 6.50
Shoe in snow, combo II.



FIGURE 6.51
Shoe prints in sand.

After the final round of photography, the cast of the impression is made. Fig. 6.50 shows the full sequence. The three photos in the center were reversed left-to-right for easier comparisons. If you were about to suggest that these photos require a labeled scale on the same plane as the depth of the shoe prints, you are correct. But, do not spray your scale with snow print wax! Add the labeled scale, at the proper depth, after the first oblique spraying of snow print wax and the "as is" photo is taken, then remove it before spraying snow print wax from all sides. Then, reinsert it before the new sequence of photos are taken.

Photographing shoe prints in sand is very similar to photographing shoe prints in snow. Sand is highly reflective, frequently resulting in an underexposure if the automatic or dedicated flash modes are used. Like snow, vertical surfaces of the sand will bounce light within the impression, frequently minimizing the shadows produced with oblique flash. For these reasons, the manual flash mode is again recommended. To help with contrast, because the normal shadows produced by oblique flash may tend to be washed out a bit, consider adding a colored spray. Snow print wax will do double duty with sand. Spraying it from one side adds contrast for the next series of images, and the wax will serve to hold the fine sand particles together during the casting process.

Fig. 6.51 shows three different footwear patterns in sand. They are showing very good patterns because the sand was wet. When sand is dry, it tends to be a bit lighter in tonality and it does not capture fine details as well because the sand easily shifts and edges lose detail.



FIGURE 6.52
Tire tracks in sand.

Besides shoe impressions, sand can display a variety of other patterns: bare foot shape, fabric patterns if someone has sat or been prone in the sand, hand prints, and sometimes even impressions of weapons. Sand can also display tire tracks, as in Fig. 6.52. This provides the perfect segue to the next section of this text.

Tire Track Photography

The photography of tire tracks shares many aspects of the techniques needed to properly photograph shoe prints. However, some additional considerations exist. Instead of an impression perhaps 10″ to 12″ long, now you may be faced with several very long impressions. The task is to ensure you document the full circumference of each tire mark present. Normally, unless you are dealing with very wide tire marks, which would suggest an oversized tire, you can anticipate the full circumference of a tire to be about 7½′ or shorter. Of course, many times only segments of a tire track may be present. But, you should know what to do with long tire marks. No more than 7½′ normally usually needs to be documented.

Those 7½′ will eventually be broken down into various segments. SWGIT's current (Fall, 2015) guideline was, "For a long tire impression, a series of overlapping photographs of 12″ each should be taken."[1] SWGTREAD did not have a recommendation for the length of overlapping photos, just casts: "36″ segments are optimal for examination. Shorter segments may also be of value."[2]

[1]SWGIT, Section 9 General Guidelines for Photographing Footwear and Tire Impressions, Version 1.0 2013.09.27.
[2]SWGTREAD, Guide for Casting Footwear and Tire Impression Evidence (03/2007), 6.3.4.2.

Before dealing with any individual segment, you need to document the entire length. Before doing close-ups of the tire track, you need to take a midrange photograph showing the tire track in relation to a fixed feature of the scene. Then, mark segments with lettered or numbered evidence markers and photograph these together in one photograph, as in Fig. 6.53. In this situation, the segments marked represent 18″ segments for photographs and casts, using the SWGTREAD guidelines for both. One legitimate criticism could be that the tape measure should be used only for establishing the segments, but not for the examination quality photographs of individual segments. That is because the tape measure is not placed at the depth of the tire track, making the enlargement of individual photos to life size problematic. However, since the casts are the correct size, the photos could be enlarged to the size of the casts. Fig. 6.54 shows the photo quickly aligned to the size of the cast, after the image of the cast was flipped to show the same orientation.

The right front tire mark can be considered one item of evidence, regardless of its length. If it is longer than 1½′ long, you will begin segmenting the entire length of the tire tract into segments. To make this easier, you lay down a tape measure next to the impression. Different tape measure increments will be included in the photographs of each segment. No more than five 18″ segments need to be documented if your agency has established an SOP of doing both photos and casts in 18″ segments. Each of the five segments will be photographed and casted, and each should be given its own designation. If the front right tire mark will be listed as evidence item #17, the five segments will be #17A, #17B, or #17.1, #17.2, etc. After photographing the entire length, you will begin photographing segments. The first segment documented will be the segment with the beginning of the tape measure alongside it. This segment will also have either the evidence marker "1" or "A" beside it. It remains to be seen what length of photos and casts the OSAC Footwear and Tire Subcommittee eventually recommends.

Although each segment is 18″ long, you do not want to miss any portion of the tire track where the different segments meet, so it is suggested to build in at least a 1″ overlap between segments. That means each 18″ segment will be bordered by a 1″ safety margin, making each photograph cover 19″of the tire track. It will be your preference whether the 1″ overlap will be on the left or right side of each 18″ segment. A 1″ overlap is not necessary on both sides of every 18″ segment. The segments can be, for example, 0″ to 19″, 18″ to 37″, 36″ to 55″, 54″ to 73″, and 72″ to 90″.

As with a shoe print, each close-up segment of a tire track will get photographed 10 times. For each of these 10 shots, a bounce card, or reflector, should be placed on the opposite side of the impression from where the flash is placed. The reflector helps the lighting quality of each shot.

- The first shot is done without a scale on the same plane. (The tape measure only helps differentiate segments. It is not on the same plane, is it?) The camera is placed on a tripod, and the sensor will be parallel to the impression.
- The recommended exposure is a slow speed ISO. If your camera has an ISO 100 option, this is fine. Sync shutter speed and f/11 are also recommended. For those digital cameras with an ISO 50 option, this may be even better.
- Manual flash or TTL flash are recommended.
- If it is sunny, block the sun from striking the impression. A piece of black cloth can be used, or someone can just stand between the impression and the sun. When the impression is located between the tripod legs, I have seen black cloth wrapped around the tripod making a teepee, where the door is placed where the flash will be coming from. This is better than just blocking the sun, because the teepee situation also blocks the light coming from the sky as well.
- A scale will be added at the same plane as the depth of the impression, and three brackets will be taken with the flash coming from between two of the tripod legs.
- The flash will be moved so it comes between two different tripod legs, and another three brackets will be taken.
- The flash is moved so it comes between the last two tripod legs, and three more brackets will be taken.

At this point the tripod can be moved to the next position, to photograph segment "2" or "B." If you wish the 1″ overlap to be on the right side of each segment, in the viewfinder you should be able to see 18″–37″.

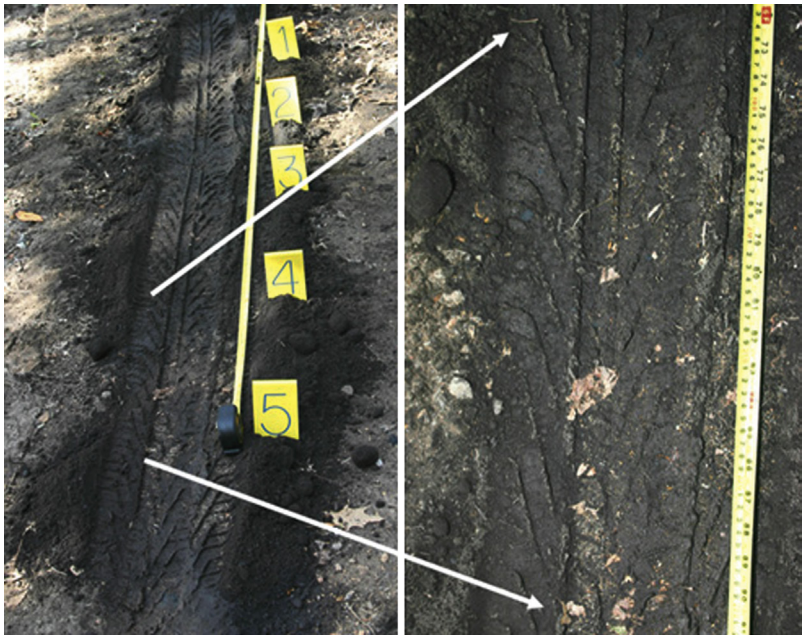


FIGURE 6.53
Tire track combo.
Courtesy of GWU MFS student Sara Dziejma.



FIGURE 6.54
Photo compared to the cast.
Courtesy of GWU MFS student Sara Dziejma.

Bite Marks

As the 3-D nature of the impression becomes less pronounced, the positioning of the light becomes more and more critical to visualizing the detail of the impression. As the impression becomes shallower, many tend to favor the light of a flashlight over the light from an electronic flash. You can be successful taking bite mark impression photographs and indented writing impression photographs with a flash unit, but you may occasionally lose an image because the flash was not aimed at the precise angle needed to visualize the detail optimally. Between the time you had determined the appropriate angle to light the impression by using a flashlight and the time you had interposed the flash unit, some slight variance in angle was introduced, and the photograph was less than successful. Many other photographs were successful. Because many hate losing any shot to this difference in the flash angle, some have considered ways to increase their success rate. What was the cause of the occasional unsuccessful image?

Obviously, because most flash units do not project a constant "modeling" light, the photographer could not see that the flash angle was improper. A "modeling" light is a light similar to a flashlight, which is constantly on. Because a "modeling" light briefly produces the shadows that will eventually be captured when the image is taken, you have confirmation the angle is still appropriate for the shot. Without a "modeling" light, you are left to hope the appropriate flash angle has been determined and that it has not changed in even the slightest degree. Many electronic flash units have the capability to emit a brief burst of light like a "modeling" light would do. Some do not even know their flash has this capability. Check out you flash's manual, and you may be pleasantly surprised.

The solution for many was to begin using a flashlight instead of a flash in those situations in which the angle of the light is very critical to the success of the image. With a shoe print or tire track in dirt, minute changes on the flash angle did not make much of a difference. As the depth of the impression becomes shallower, the angle of the light becomes more and more critical.

It should not be suggested that every use of an electronic flash should be eliminated in these situations. Many photographers produce some very fine images by using an electronic flash with impression evidence. It is suggested you try using a flashlight in these situations to see whether your success rate improves also. This author's did; perhaps yours will also.

Because bite mark photographs are examination quality photographs, the camera should be placed on a tripod to help ensure critical focus is maintained while you are busy maintaining that critical angle with the flash or flashlight. In these situations, ISO 100 film is suggested, and f/11 is the recommended f/stop. Before the series of close-up photographs is begun, a midrange photograph, showing the bite in relation to a known body part, is taken. This can be a joint or other body part that does not compromise the modesty of the victim. This midrange photograph is required to establish just where on the body all the close-up photographs are coming from.

Then, take a series of close-up photographs. This is the perfect time to select the aperture priority exposure mode. If the relatively dim flashlight causes the need for longer shutter speeds, the camera on a tripod ensures the long shutter speeds do not result in blur. Actually, slow shutter speeds are a benefit when using a flashlight as your light source. A flashlight often has a characteristic beam of light that is not uniform. During a slow shutter speed, quickly fanning the flashlight beam over the evidence causes the distracting flashlight beam to be transformed into an even lighting all over the evidence, rather than producing streaky lighting.

Fig. 6.55 shows another frequent problem that occurs with bite marks on skin. Because the area of the skin is often curved, it is hard to properly focus on the subject matter, which is different distances from the camera, and it is difficult to uniformly light a curved bite mark. For this reason, the upper and lower arches are usually considered **different** items of evidence because it is difficult to compose and properly light both arches in the same image. It is still wise to show them together in one photograph, although this may not be the best image of either arch. Then, each arch is photographed separately with a series of brackets. The camera can meter the bite mark lit by the flashlight to get the beginning shutter speed. Take that photograph without a scale. Add a scale, then bracket with another photograph at the "proper" exposure, and add a +1 and −1 exposure.

Fig. 6.55 also shows two different bite marks with two different scales. The preferred scale to use with bite marks is the ABFO No. 2 scale, as shown in Fig. 6.55A. The three circles incorporated into that scale's design allows for corrections to be made in images which were not photographed with the film plane parallel to the scale.

Some have noticed that most bite mark photographs show more detail within the bite mark when the images are a bit underexposed. Give the odontologist working the case more "tools" to work with, and add a −2 exposure to your collection. Fig. 6.56 shows a series of images bracketed toward a −2 instead of the normal +1 and −1 brackets.

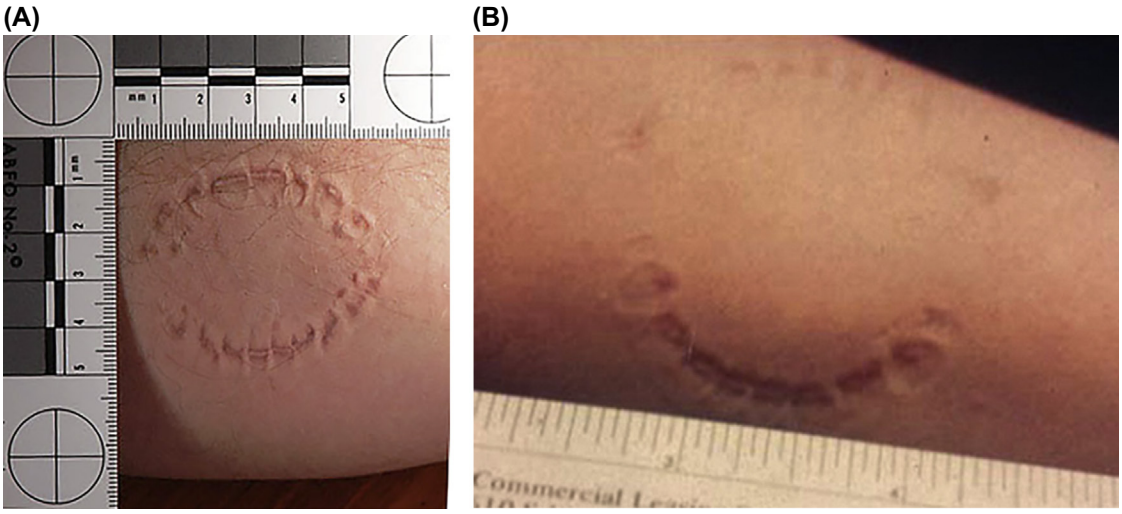


FIGURE 6.55
(A) Bite with ABFO No. 2 scale. (B) Bite on curved skin. Not good for either arch.

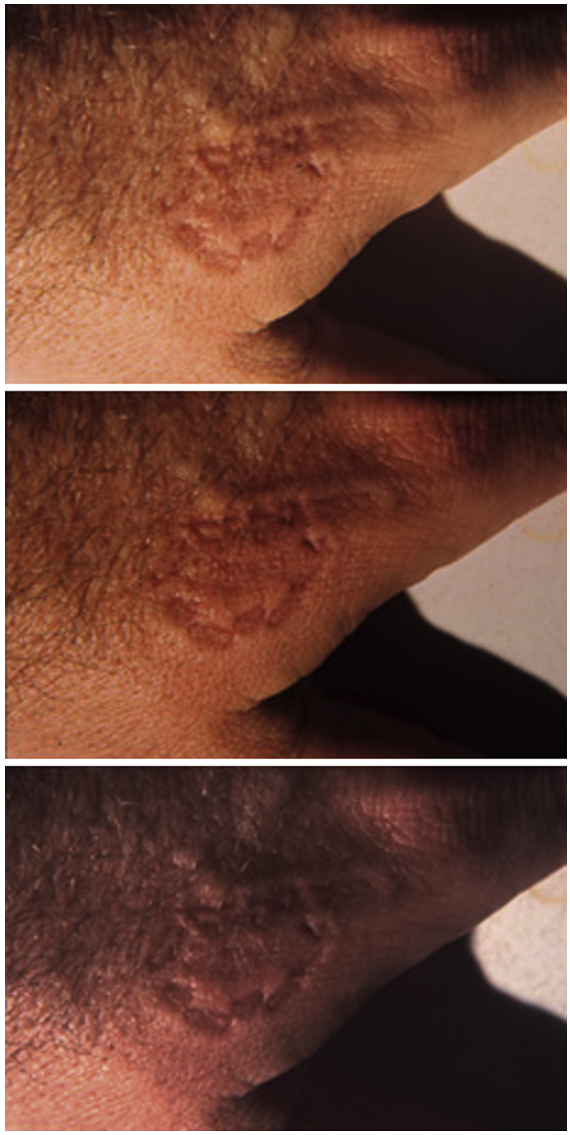


FIGURE 6.56
Bracketing toward –2.

Fig. 6.57A shows one arch photographed with the flashlight moving during the exposure. The normal flashlight streak is gone, and the entire area looks evenly exposed. Fig. 6.57B shows the same bite mark successfully lit by electronic flash. It certainly can be done. Notice the distinct difference in colors in these two bite marks. As expected, Fig. 6.57A shows the "warmer" yellow tint caused by the flashlight's tungsten filament, which does not look bad with some Caucasian skin tones.

Although this is a text on photography, the crime scene photographer often has other duties at crime scenes. This may include "collecting" the bite mark by other means than photography. Of course, before touching the bite mark, you should swab the area to collect any saliva present for DNA tests. After that, if the bite marks have not pierced the skin, consider casting the 3-D bite mark with a silicone rubber compound like Mikrosil or Accutrans. Although these are a dental-grade silicone rubber designed to be put into patients' mouths, your agency may have prohibitions to using such techniques around broken skin or open wounds. In addition to casting the bite mark, you may also powder and tape lift the impression. See Fig. 6.58. Parts of this image have been flipped and rotated to align them all side-by-side for easier viewing.

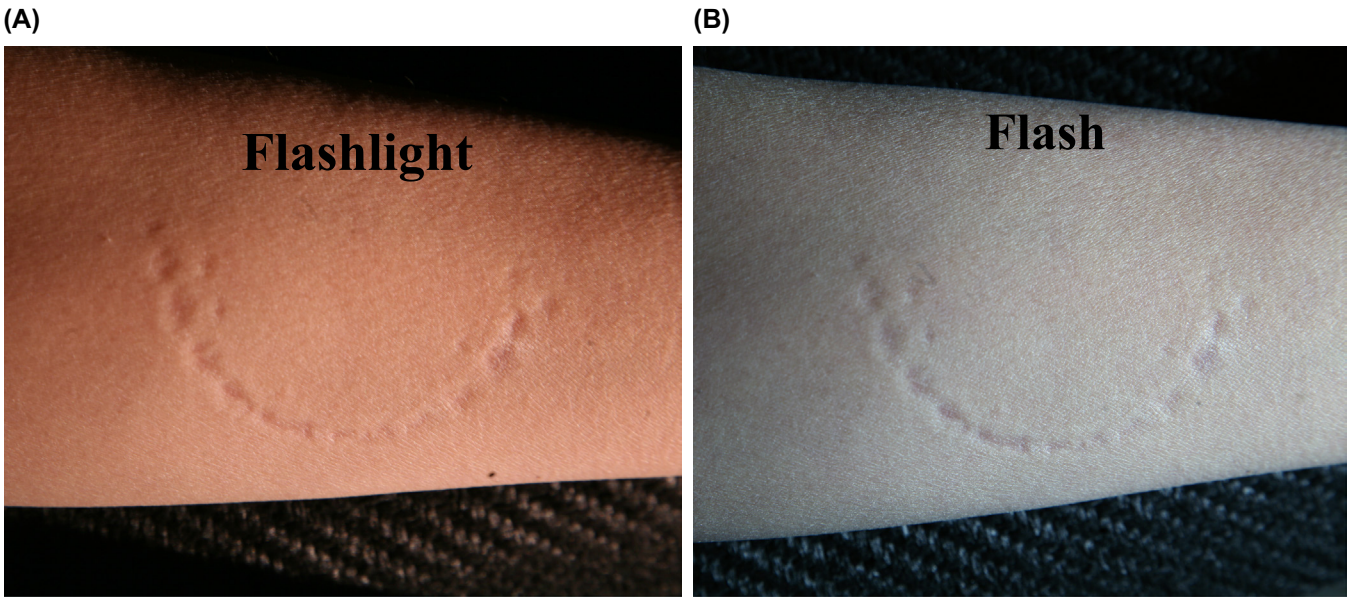


FIGURE 6.57
(A) Bite mark lit with flashlight. (B) Same bite mark lit with flash.

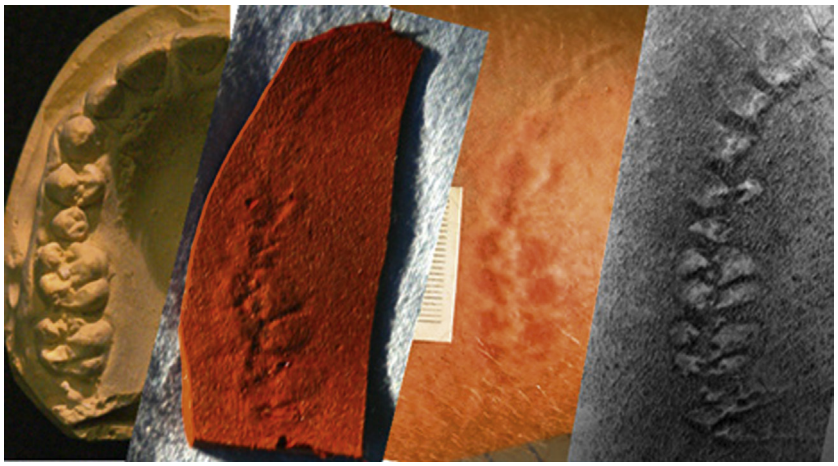


FIGURE 6.58
Combo: Castone, Mikrosil, photograph, powder, and tape lift.

Some may not yet use the powder and tape lift method to document a bite mark. This is best done with black powder and a fiberglass filament brush. The intent is to use the brush tips to darken the raised skin and leave the impressions with less powder, providing contrast. See Fig. 6.59 for additional examples of the great detail which can be recovered this way. Try it; you will like it. Of course, before lifting the powdered bite mark, photograph it.

And, not only skin can be bitten by suspects. Fig. 6.60 shows two purses that were stolen during a burglary. As the suspect crawled out the window to flee the scene, he temporarily held both purses in his mouth. He "tooled" each purse with his teeth. The suspect was later positively identified to the purses by his bite marks.

Many times, food products may be partially eaten, with bite marks remaining on the unconsumed portions. These can be photographed, swabbed, and casted. Fig. 6.61 shows one such example. Recently, in the Washington DC area, the Metropolitan Police Department had a similar bite mark case successfully resolved in a triple homicide case. In this instance, the bite mark evidence left behind was a partial slice of pizza. I just mentioned, above, this type of evidence should be photographed, swabbed, and casted. In this case, the DNA from the swabbing around the bite mark to the pizza lead to an identification.

It is good to remember that with bite mark photography, with the camera on a tripod, and close to the impression, if you are using a flash to light the impression, keep the flash at least 2′ from the impression. Any closer and the image will tend toward overexposure.

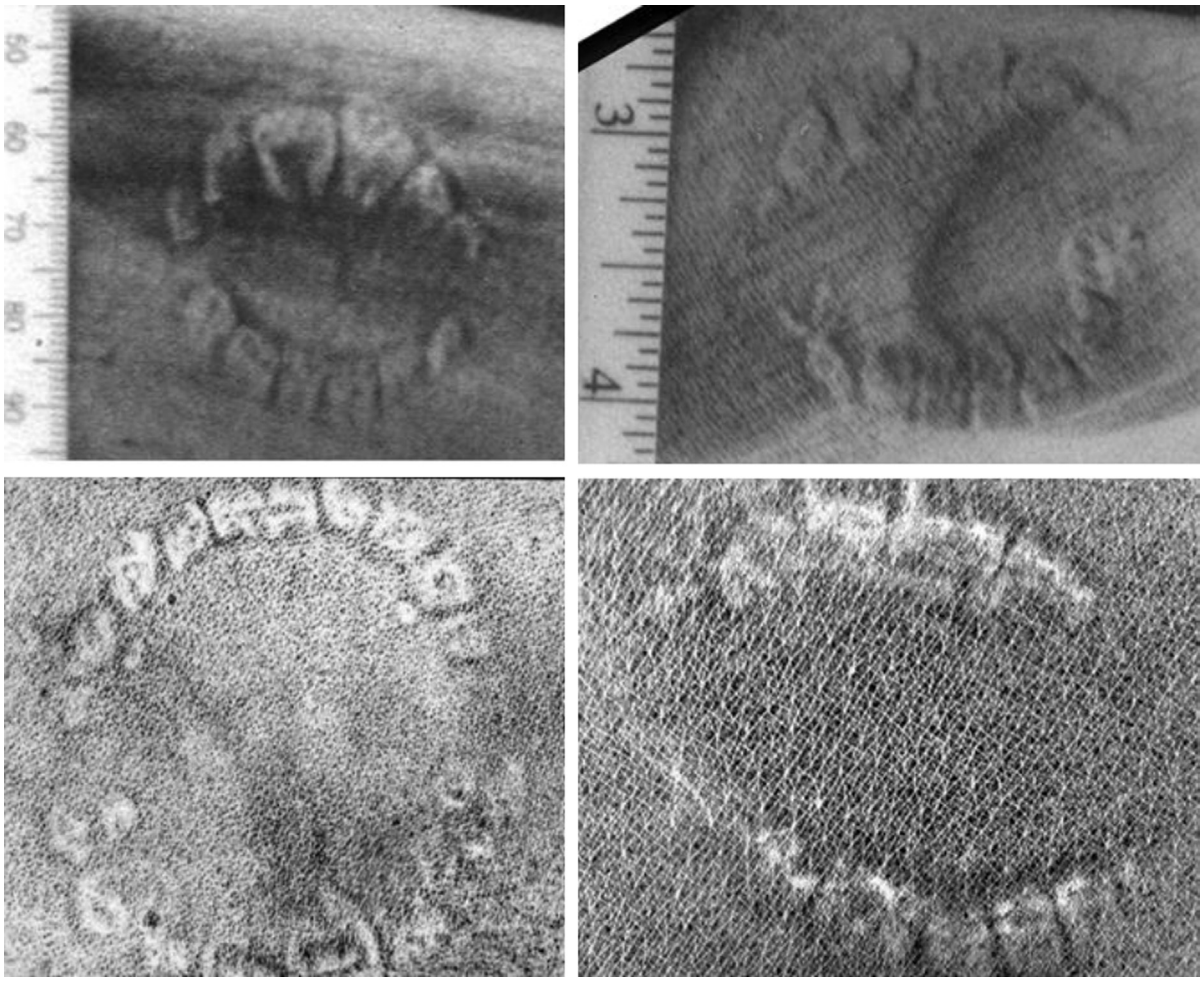


FIGURE 6.59
Powdering bite marks prior to tape lifts.

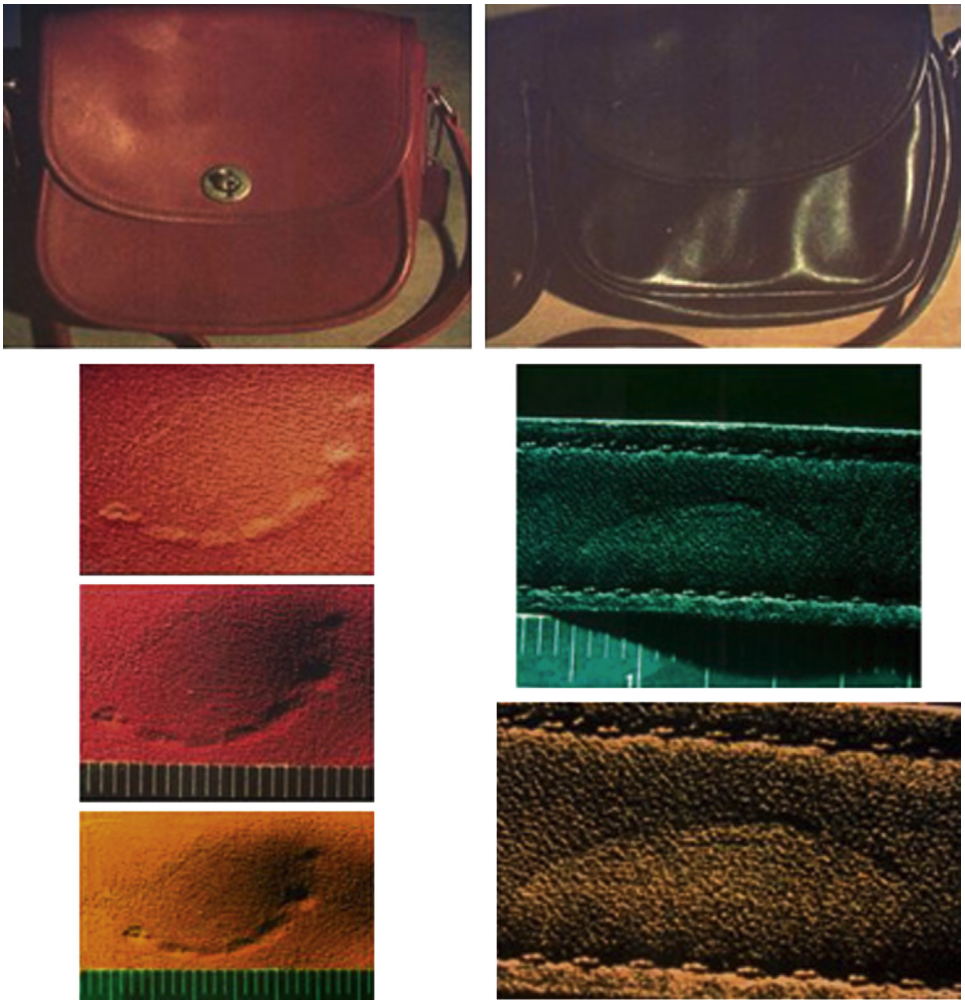


FIGURE 6.60
Stolen purses.
Courtesy of the Arlington County Police Department, Arlington, VA.



FIGURE 6.61
Bite mark on candy.
Courtesy of GWU MS student C. McGillivary.

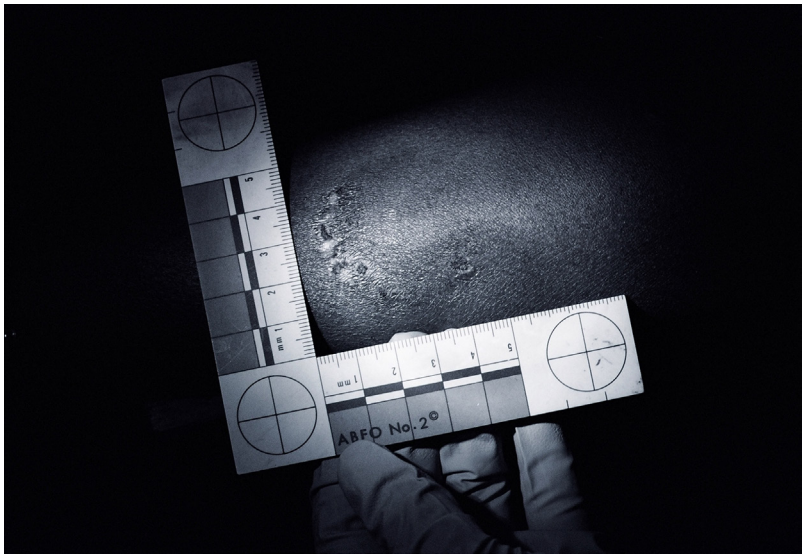


FIGURE 6.62
Bite mark with ABFO No. 2 scale.

One cannot leave a section on bite mark photography without rementioning one of a dentist's favorite "tools," created by the American Board of Forensic Odontology: the ABFO No. 2 Scale. It is shown, again, in Fig. 6.62. It is the preferred scale to be used when photographing bite marks.

Indented Writing

With very shallow 3-D types of evidence, like indented writing, the angle of the flashlight becomes even more critical. An almost parallel angle of the flashlight to the paper on which there is indented writing is required to properly visualize the fine impressions. Again, you can be successful in photographing indented writing with a flash. Some flash shots may come out improperly highlighting the indentations because at times the light from the flash may "miss" the indented writing. You may increase your success rate by switching to a flashlight.

One aspect of visualizing indented writing must first be considered before we discuss the proper exposure for this situation. When the words have been printed, and even with cursive, there are many vertical and horizontal aspects of many letters. If the light of the flashlight goes down a depression in paper, the effect is similar to lighting a shoe print in dirt with a direct flash. If the depression is fully lit, it will be difficult to see from the camera's position above the paper. When the light from the flashlight strikes the depression from a perpendicular angle, it will create a shadow, and that part of the letter will be easily seen from the camera's position.

Fig. 6.63 provides a good example. The word "Hello" is predominantly made with vertical and horizontal letter elements. If the light from a flashlight comes from either the left or right side of the paper, the horizontal elements become almost impossible to see. If the light comes from the top or bottom of the paper, the vertical elements of the letters will be washed out and difficult to see. A compromise is called for. Usually, lighting indented writing from a diagonal view, or from one of the corners of the paper, will best visualize the letters. Of course, simply moving the flashlight around the paper will show this.

Fig. 6.64 reiterates the need to keep the flashlight moving during the exposure to avoid the flashlight streak produced otherwise. An entire sheet of paper can be evenly lit if the flashlight is kept moving.

What is the recommended exposure for indented writing on white paper? ISO 100 film and f/11 are standard elements of an exposure when the evidence may ultimately be used for examination quality photographs. The camera is positioned on a tripod, with the sensor parallel to and over the evidence placed on the floor. The evidence is placed on a clean substrate, like brown packaging paper, not directly on the floor, where the evidence can be contaminated. In the first photograph you should compose on the entire sheet of paper. This is to ensure there is no other writing on the page, which may be questioned in court.

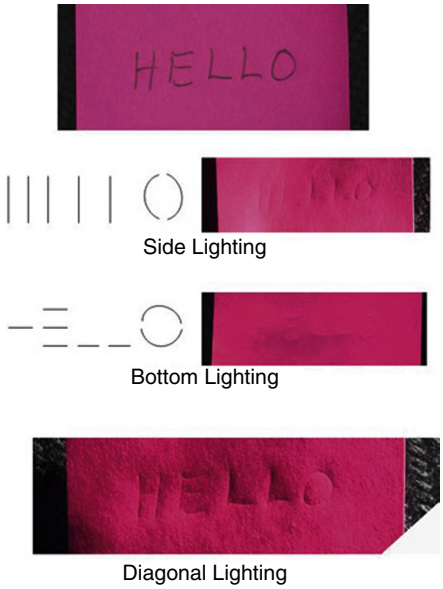


FIGURE 6.63
"Hello" lit from three directions.



FIGURE 6.64
Flashlight: static and moving.

In this case, it is not the paper that you want to be properly exposed, so the aperture priority mode is not recommended, which would try to properly expose the paper, not knowing it is the indented writing you are truly interested in. With a rechargeable Mag Lite or Streamlight, flashlights frequently issued to crime scene search personnel, set a 2-s shutter speed on the camera. Because the paper is white and highly reflective, the flashlight should be moved to about 6′ from the paper. The shutter can be set to a 10-s delay, which will give you ample time to walk 6′ away, get the flashlight almost parallel to the floor, and direct the flashlight from one corner diagonally to its opposite corner of the paper while moving the flashlight during the entire 2-s exposure.

Fig. 6.65 shows a typical result. Perhaps this suspect was apprehended between robberies because in his pocket he still had another similar note to the one left at one bank robbery when he was apprehended within an hour of that robbery. A pad of paper in his apartment had indented writing on it that showed aspects of both notes.

It is recommended a scale be laid alongside the full sheet of paper for the first photograph, so it does not cover any of the paper. After that, if you would like close-ups of particular words, you can take additional photographs.

The entire sequence of close-up photographs is therefore as follows:

- An image of the full sheet of paper, with a scale alongside; ISO 100 film; f/11; flashlight 6′ away from the paper, aimed diagonally from one corner to another diagonal corner, almost parallel to the floor (so the indentations are clearly "shadowed"); 2-s shutter speed.
- +1 bracket: 4-s shutter speed.
- −1 bracket: 1-s shutter speed.
- Another series of brackets (0, +1, −1) with the flashlight coming from a different, but not opposite, corner. Photographing from the opposite corner will give results similar to the first series of photographs. The idea with the second series of photos is to visualize letters that were perhaps not adequately visualized in the first series.
- Additional shots composed on selected partial phrases or individual words as desired, all with scale.

It must be added that the paper is never handled with your bare hands. Besides the indented writing, there are possible fingerprints on the paper which are just as valuable as evidence as visualizing the writing.

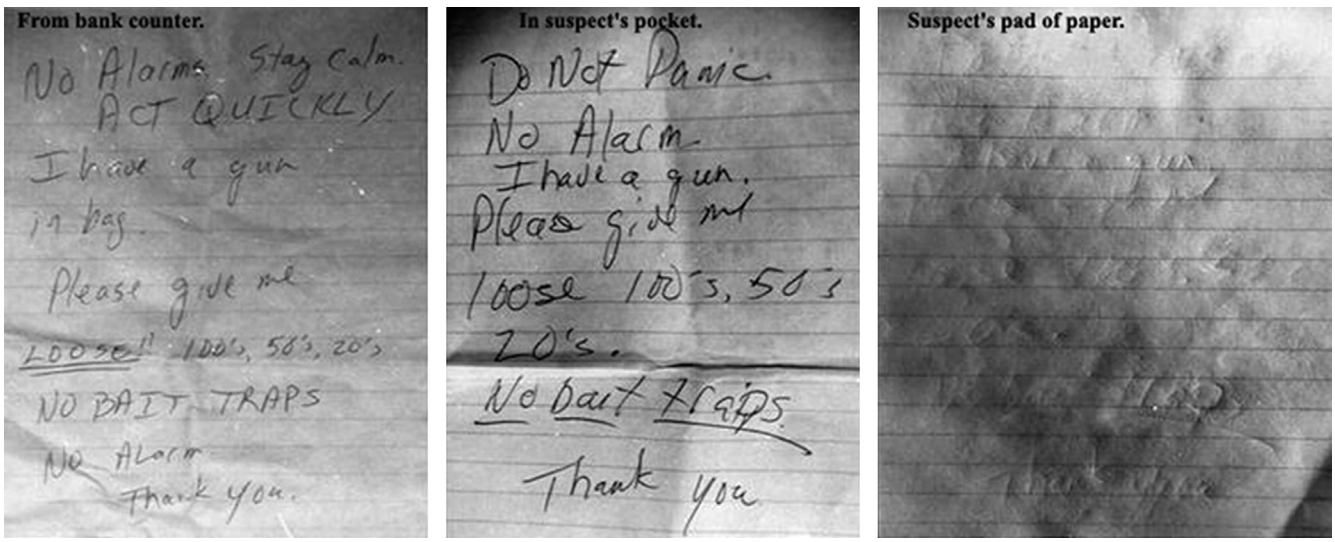


FIGURE 6.65
Indented writing example: bank robbery.
Courtesy of the Arlington County Police Department, Arlington, VA.

Dust Print Photographs

Perhaps the shallowest type of 3-D evidence a crime scene photographer will be required to photograph is a dust print lift. Dust sitting on top of a nonporous surface is, indeed, a 3-D type of evidence. In this case, however, it is not shadowing that will reveal the dust print. Oblique light must highlight the dust itself. It is necessary to enhance the contrast between the dust and the substrate it is currently on, which can be the floor at the crime scene or the black Mylar film of a dust print lifter used to attract the dust from the original surface.

If the dust prints can be visualized "as is," they should be photographed "as is" before lifting them. Many times, however, a dust print is located after a blind search for shoe prints in an area suspected of having shoe prints, but where none can originally be found. Several electrostatic dust print lifters are available on the market, and most seem to recover such dusty prints pretty well. Once the dust print is on the black Mylar film, perhaps the first thing that should be noted is that there has been a left-to-right reversal. A dust print appearing to be a right shoe was made by a left shoe, and vice versa. Fig. 6.66 shows a dust print and the shoe that made it. **Is this true?**

Actually, in the previous second edition of this text, the image that was presented as Fig. 5.85 is now presented as the left and middle images of Fig. 6.66. After just a quick look at the original image from the second edition, it was very apparent that the shoe shown could **not** have made the dust print next to it due to two reasons.

- Dust prints are left-to-right or right-to-left reversals. The dust print in the middle of Fig. 6.66 appears to be a left shoe, so it was really made by a right shoe. The shoe on the left of Fig. 6.66 is a left shoe!
- The wear marks of the shoe in Fig. 6.66 are not duplicated in the dust print lift.



FIGURE 6.66
Did this shoe make this dust print? No!

To make this obvious to all, I flipped the shoe on the left and added it to the right of the dust print. Both shoes images are the same shoe, one has just been flipped. Now, it becomes very apparent that the shoe tread pattern from either shoe did not make the dust print in the center. Flip the shoes or flip the dust print; it does not matter. The shoe tread pattern you are seeing on either shoe could not have made the dust print. I made a mistake; and now I am correcting it. However, the point that I was trying to make is still true. Look just at the dust print for a second. If it were a bloody shoe print, or a grimy residue transfer to a surface, with this pattern it would have been made by a left shoe. However, as a dust print it would have been made by a right shoe. The shoe on the left is a left shoe; the shoe on the right is the left shoe flipped to appear to be a right shoe. However, neither shoe made this dust print.

This left-to-right reversal must be mentioned in your notes because there will be times when the photograph of a dust print is not obviously a photo of a dust print lift, and it is essential the shoe print examiner compare the photograph to the correct shoe.

Another interesting aspect of dust prints is that they may be a **Positive Dust Print** or a **Negative Dust Print**. A positive dust print is made when a dusty shoe leaves its residue on a relatively clean surface. The shoe print is the dust. A negative dust print is made when a dirty surface is walked on and the shoe or foot removes dust in the shape of the shoe or foot. Either a positive or negative dust print can be identified (see Fig. 6.67).

Here, again, some have switched from using an electronic flash to using a flashlight to visualize a dust print to be photographed. This author was originally taught to use an electronic flash, and many of my images came out fine. Too many times, however, the flash improperly lit the entire shoe print. Because it was possible to light the dust print with a flashlight in a way that lit the entire shoe print well along its entire length, it made sense to consider this lighting technique to capture the image in a photograph as well. It just became necessary to determine the shutter speed necessary for a proper exposure. The camera is set to ISO 100; and the f/stop was going to be f/11 to avoid any diffraction problems. A Mag Lite or Streamlight flashlight was the light of choice. If you use a different flashlight, you will have to adjust this shutter speed recommendation for your flashlight.



FIGURE 6.67
Positive and negative dust prints.
Courtesy of GWU MS student M. Hendricks.

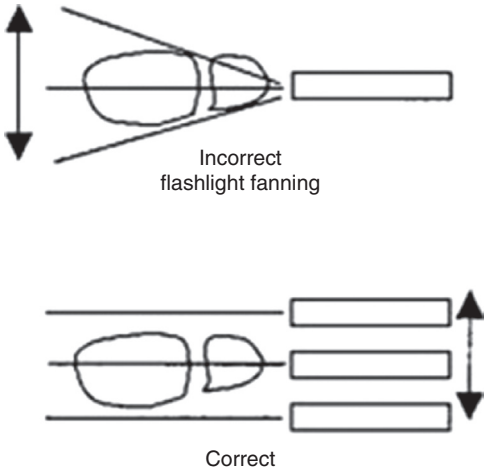


FIGURE 6.68
Incorrect and correct flashlight movement over dust prints.

It was known that the flashlight would have to be moving to avoid the streaky look of a nonmoving flashlight. Fanning the flashlight by moving the flashlight in an arc shape was first tried, but soon it was noticed that this technique usually resulted in the part of the dust print closest to the flashlight being overexposed because it was receiving light the full duration during a long exposure, while the opposite end of the dust print was only partly lit by the fanning action and tended to be underexposed. So it was necessary to have the flashlight moving while it remained parallel to the long sides of the shoe print. Fig. 6.68 shows both the correct and incorrect methods of moving the flashlight during the exposure. Trial and error was used to determine the proper exposure for a dust print lift; it turned out to be 6 s. A +1 bracket, then, would be 12 s, and A –1 bracket would be 3 s. These brackets are all with the flashlight being about 6″ to 1′ from the heel or toe of the dust print.

One other aspect of these long exposures became apparent. Because the labels on the scale, placed parallel to one of the long sides of the dust print, are usually white, these frequently became quickly overexposed. Two preventive cures were developed. As the flashlight is being moved over the dust print, parallel to the right and left sides of the print, try to avoid it coming to the point where it actually directly lights the scale. Try to avoid having the strongest part of the flashlight beam light the scale. A second method to keep the scale from becoming overexposed is to write the identifying information usually put on the scale in bolder black lines. If a bold Sharpie pen, or the equivalent, is available, use it. Then, wherever the label is pure white, cover most of it with black ink.

The recommended sequence for a dust print lift, then, is as follows:

- Without a scale in place, take the first image with ISO 100 film, f/11, and the flashlight panning the dust print for 6 s.
- Add a scale and take another "0" exposure.
- Bracket +1: 12 s.
- Bracket –1: 3 s.
- Take a "0" exposure from the left side, if the first series of four images was with the flashlight coming from the right of the dust print.
- Bracket +1 from the left side.
- Bracket –1 from the left side.

During the exposures, ensure the flashlight is uniformly lighting both the heel and toe of the dust print at the same time. With just a little practice, your success rate of well-exposed dust print images will rise drastically.

Dust prints can be lifted from hard surfaces like linoleum, parquet wood, oak strip floors, tile, and cement. They have also been lifted from fabric when clothing has been stepped on, or when a victim has been stomped on (see Fig. 6.69). In a test, dust prints have also been successfully lifted from skin after a recent "stomping" incident.

A nonelectric technique is required to lift prints from live skin. The Lynn Peavey Company, a crime scene product distributor, makes Stati-Lift, which is perfect for this application. It is made up of two layers of plastic, one clear and one almost as opaque as the Mylar film used with other electric dust print lifters. Just by separating the two sheets of plastic with the tabs provided, a static charge is applied to both sheets of plastic. Squeegee the darker layer over the dusty impression with one hand, and the dust transfers to the film (see Fig. 6.70).



FIGURE 6.69
Dust print from T-shirt.
Courtesy of GWU MFS student V. Hart.

In addition to the Stati-Lifts, a newer product works just as well. Called Cling Film, it comes from a plastic distribution company. Again, it is just two sheets of plastic, which can be ordered in various sizes. Before the news traveled through the crime scene investigation pipeline, and the orders began to grow, 50 sheets of the Cling File, about 9″ × 12″ was just $50.00! Count on the price being higher now.

Two of my students, Stephanie Kingsbury and Emily Moon, wanted to do a project for a class on something related to dust print lifters. I asked them to think about an unusual surface that a dust print might be left on. We came up with the idea of a female homicide victim lying on the floor as the murderer walked around her body admiring his handiwork. As he walked around her, he also stepped on her hair, which was long and radiated outward from her head. Could a dust print be left on her hair? Just one way to find out: Emily killed Stephanie and stepped on her hair as she walked around her and admired her handiwork. Fortunately, there was a guy nearby with a camera to capture this. One sheet of Stati-Lift was used to try to recover any dust which had been transferred to Stephanie's hair. Fig. 6.71 is the result! We were very pleasantly surprised. Although we tried to duplicate this, all subsequent attempts were unsuccessful. It seemed once Stephanie's hair had been charged with static once, further dust prints would not transfer to her hair. This does seem to have great potential for further research.



FIGURE 6.70
Dust print from skin.
Courtesy of GWU MFS student J. Sinex.



FIGURE 6.71
Dust print from hair.
Courtesy of S. Kingsbury & E. Moon, GWU MFS students.

As the surface becomes more and more dusty, one would expect that successfully lifting a positive dust print becomes more difficult or impossible. Walking across a carpet that is very dusty will not produce dust prints of value on adjacent portions of the carpeting. Stepping from a carpeted floor onto upholstered furniture will also not usually transfer a dust print. Walking across that same carpet and then stepping onto the linoleum kitchen floor will usually leave a great dust print.

One final aspect of dust print lifters must be mentioned. Students have been able to retrieve dust prints with detail after the dust prints have been made, and then left several days to simulate a time period between a crime being committed and the crime being discovered. Subsequent falling dust may cover dust prints to the point they are no longer visible. In these situations, a first or second dust print lift may remove the extraneous dust covering the dust print of interest. Recognizable shoe print patterns have been recovered up to 43 days after the original dust print was left on a surface. Additional snow falling on top of a shoe print in snow will effectively fill in the impression, making it impossible to recover the original shoe print. However, additional dust falling over a dust print does not eliminate the possibility of recovering some shoe print detail with multiple dust print lifts. Fig. 6.72 shows this result, 43 days after the original dust print was left on a floor!

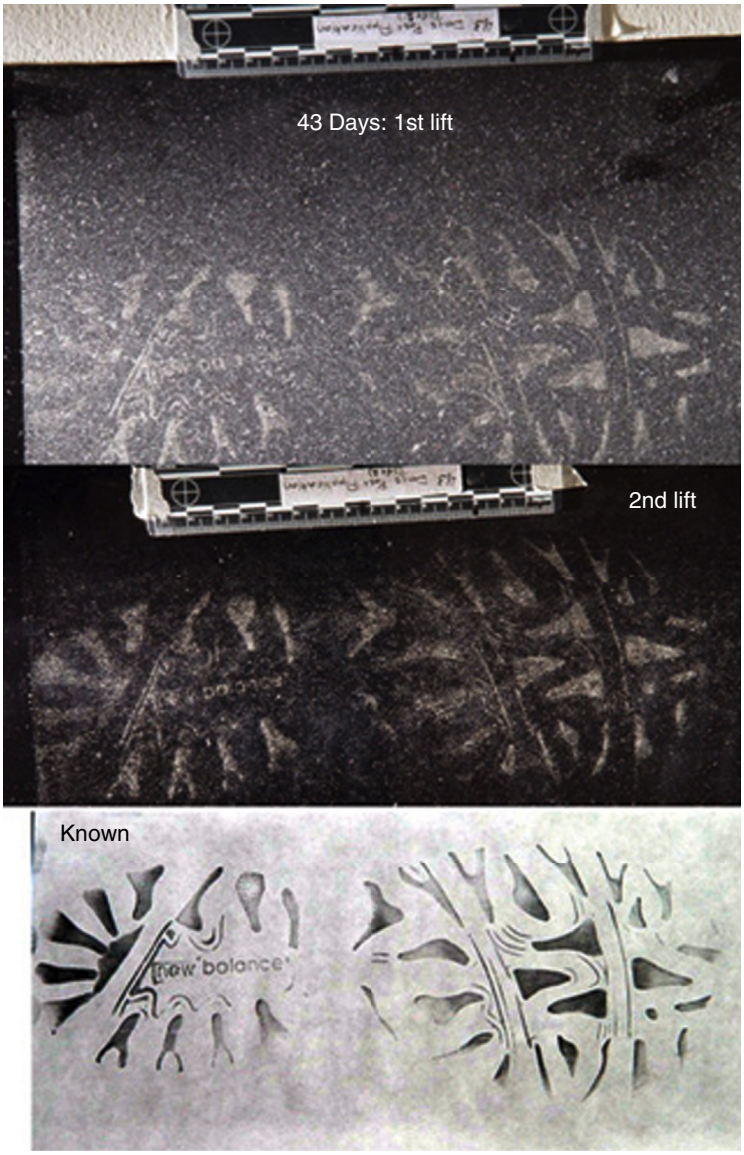


FIGURE 6.72
Second lift better than the first.
Courtesy of GWU MFS student Carolyn Sikorski.



FIGURE 6.73
Dust print of a shoe print fingerprint.

Just before leaving this section on dust print lifts you get to see this author's favorite dust print lift ever. In our classes, we spend much of our time lifting dusty shoe prints, so to find something a bit different is always gratifying. In this case it is a dusty fingerprint! See Fig. 6.73.

BOUNCE FLASH

When to Use Bounce Flash

Using an electronic flash so that it is aimed directly toward the scene of interest is usually a very efficient way to light a crime scene. Several situations exist in which doing what is "normal" may actually produce unacceptable results, however. If a mirror is in the scene, aiming an electronic flash toward it may cause the reflection of the mirror to be seen in another area of the scene. This mirror reflection may be so distracting that it overwhelms the intent of the photograph. A mirror can be a problem, even if it does not throw its own reflection elsewhere into the scene. When direct flash strikes many objects, a shadow is produced behind that object. Our eyes are so used to this that we hardly notice it. If a mirror is in the background, the light reflecting from the mirror can now create a shadow in front of the object as well. When the same object has more than one shadow, it looks a bit strange and becomes distracting. Figs. 6.74 and 6.75 show both of these effects, with bounce flash used to eliminate the distracting elements of each.

Mirrors are not the only causes of these types of problems. Many highly reflective surfaces may be present in a crime scene. The crime scene photographer will eventually be able to anticipate these problems and use bounce flash to overcome the problems that would be created by these reflective surfaces. Metallic surfaces are highly reflective. When struck by direct flash, they can develop a "hot spot" or glare from reflection. The glare can be eliminated if light softly washes over the same area from the ceiling. Fig. 6.76 shows this effect and the cure: bounce flash.

Fig. 6.77 shows the effect of a direct flash aimed at "evidence" on a glass-topped table. The reflection of the tabletop is thrown onto the wall behind the table. Bounce flash eliminates this distracting reflection. Whenever glass is in the field of view, it can behave similarly to a mirror and reflect light elsewhere in the scene. Be cautious with furniture covered with glass anywhere in the scene.

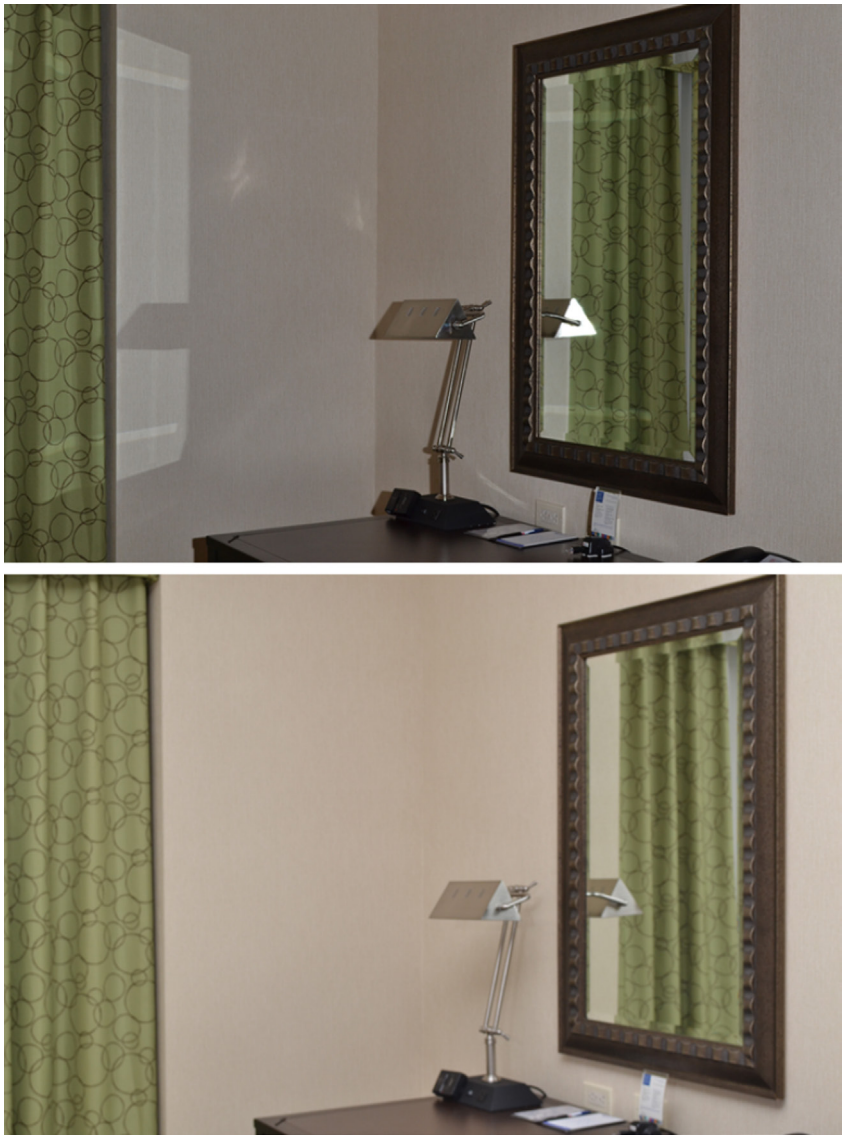


FIGURE 6.74
Mirror reflection appearing in background.
Courtesy of GWU MFS student M. Hashemi.

Liquids are also highly reflective and will bounce the light of a direct flash unpredictably around a scene. One example ought to suffice for this concept to be remembered. An unhappy foreign national learned he was going to be deported and entered a US Immigration Office lobby prepared to negotiate his case. He carried a 5-gallon gas can, a Bic lighter, and a razor blade. As he began dousing the lobby with the gasoline, the lobby cleared quickly. He then slashed one wrist with the razor blade and lit the lighter. He said he wanted officials to reconsider his deportation quickly, before he lost enough blood to faint, drop the lighter into the gasoline, and light it. Because the cut wrist did not appear to be too bad, time was on our side, and a negotiator was called in to deal with the subject. The fire department eventually staged outside a wooden lobby door with a high-pressure, wide-spray water hose; on cue, firefighters opened the door, doused the subject and his lighter, and the subject was subdued. The lobby was now wet with water and blood, and an interesting rainbow of gasoline floated on all the other liquids. To illuminate that crime scene with a direct flash would have produced many interesting, though distracting, reflections. Bounce flash was the only way to photograph this scene.



FIGURE 6.75
Direct flash shadows cured by bounce flash.
Courtesy of GWU MFS student J. Kirk.



FIGURE 6.76
Hot spots and uneven lighting cured with bounce flash.



FIGURE 6.77
Glass-top table with direct and bounce flash.
Courtesy of GWU MFS student T. Black.

Bounce Flash Is Dim Light

If you need to light a crime scene with a flash bounced off the ceiling, the light must travel further than normal. It must travel from the flash head to the ceiling and then reflect down onto the surface of the scene of interest. The ISL teaches us that when light goes further to get to its destination, it is dimmer when it gets there. This is, unfortunately, just one cause of the dimness of bounce flash.

A difference exists between direct flash lighting an object at *x* distance and bounce flash lighting the same object at that same total *x* distance. Would you not expect that direct flash would be brighter than bounce flash at the **same** distance? In other words, even if the distance the light has to travel to reach the subject to be photographed is 20′, direct flash traveling 20′ is brighter than bounce flash traveling a total of 20′. Why?

Direct flash is very effective at lighting its subject matter. The light proceeds directly from the flash head to the subject matter. When the flash is aimed at the ceiling and bounces from it downward toward the scene of interest, it is diffused wider than the direct flash beam of light. Some of this light striking the ceiling bounces away from the intended target. Some of the light is lost to the surroundings that may be outside the area of the particular image that has been composed in the viewfinder. Because this light misses the subject altogether, the light that does fall on the subject is dimmer still.

Also, many ceilings are not just solid surfaces painted white. Many ceilings, particularly in offices, are made with acoustical tiles. Being porous so they will absorb sound, they can also absorb light. Some of the light striking acoustical tiles will be absorbed and never reflect from the ceiling. This also diminishes the light eventually reaching the subject matter. Bounce flash is dim light.

Compensating for Dim Bounce Flash

With less light reaching a crime scene area, an exposure compensation must be made to ensure there will be proper exposures. Because these photographs are being taken inside, you have probably already set your camera to ISO 400. If you are using a digital camera, it would be possible to bump up the ISO rating to ISO 800 for the bounce flash shots to help compensate for the lost light. Remember to reset the camera for the normal ISO 400 film speed after the bounce flash shots are over.

The shutter speed is locked to sync speed, so the exposure compensation necessary must come from somewhere else.

Set the flash for the manual flash mode. The automatic exposure flash mode and the dedicated exposure flash mode allow for the possibility for less light than the manual flash mode, but because the light loss can already be significant with bounce flash, avoid any further light loss, and do not use these other flash exposure modes.

Only one camera variable is left to compensate for the light lost because of the use of bounce flash. It will be necessary to open the aperture to let in more light. To use a wider aperture, you must first establish what the "starting" aperture is. Because it is necessary to know the distance the light will have to travel, the first step is to calculate the flash-to-bounce surface-to-subject distance.

A couple of ideas must be dealt with here, and both deal with minimizing the distance the light has to travel.

First, take the flash off the camera's hot-shoe. If you use the flash connected to the camera with a PC or remote flash cord, you can hold the flash at arm's reach aimed at the ceiling, and this can help minimize the distance the light has to travel. The closer the flash unit is to the ceiling, the shorter the distance it has to travel, and the brighter the light will be when it finally gets to where it is needed.

Now, where do you aim the flash? The optimal location on the ceiling to aim the flash, to minimize the total distance the light has to travel, is at a point midway between you (the photographer) and the subject matter. If you had a rubber ball and threw it at the ceiling to strike this location, it would bounce down and hit the subject directly. At times, however, this will not work. There may be a concave light fixture there, or there may be a hanging fixture just beyond this halfway point that would block the light striking the midpoint on the ceiling. Nevertheless, if the midpoint is not obstructed in any manner, it is always the most efficient direction to aim the flash head. If some obstruction makes the midpoint unusable, you should consider other options, the next being a point on the ceiling one third the distance between you and subject. If that will not work, you should consider a point directly over your head. If neither of these will work, you will be forced to consider aiming the flash at a wall either at one side of the subject or behind you so the light can bounce directly on the subject matter without your casting a shadow over the subject matter (see Fig. 6.78).

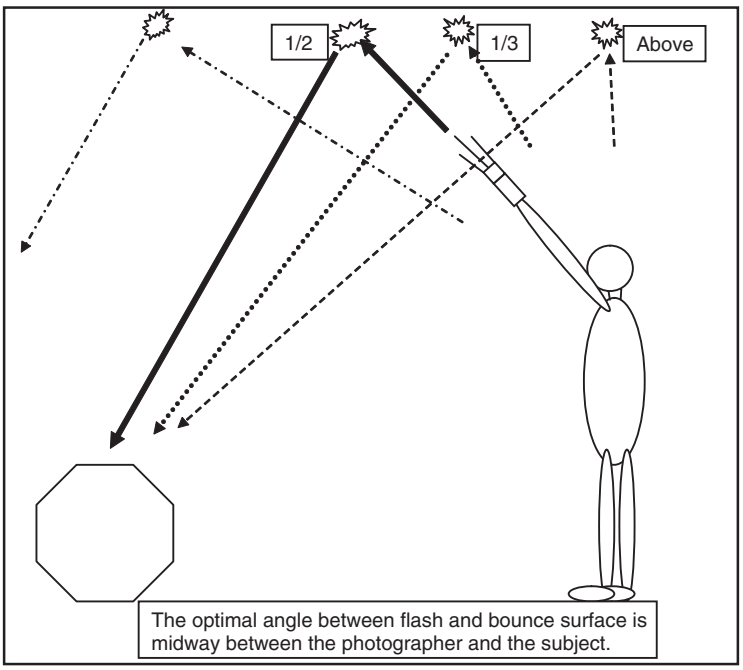


FIGURE 6.78
The optimal bounce angle.



FIGURE 6.79
Manual flash exposure recommendations on LED panel.
Courtesy of Craig Wineman, Manager, Penn Camera, Fair Lakes, VA.

Where should the flash never be aimed? The flash head should not be positioned to bounce the light beyond the halfway point between you and the area of interest. This would cause the light to bounce down from the ceiling behind your subject of interest and may either backlight your subject and throw it into shadow, or the light may not light the subject at all.

With the flash held at the optimal angle toward the ceiling, mentally calculate the flash-to-bounce surface-to-subject distance. Make note of the manual flash f/stop recommendation for this distance, which is merely the beginning point, not the f/stop that will actually be used. Remember, several dimming factors are present in addition to this new distance the flash will be traveling.

With this f/stop in mind, set the camera for 2 stops wider than what is recommended, if the bounce flash photo is being taken in a "normal" room. This will compensate for the less intense bounced light. Why two stops? Trial and error has determined this is a good starting point.

When taught bounce flash in the late 1970s, this author was advised that after the +2 stop exposure was taken to bracket with both a +1 and −1 from this point. However, the −1 bracket was never the best of the three shots, so it is no longer recommended. Just do a +1 bracket. That means, in effect, to determine the flash-to-bounce surface-to-subject distance, see the f/stop necessary for that distance, and then open 3 stops. This will be a +1 bracket.

Let us return to the manual flash exposure recommendation on the LED panel for an example (see Fig. 6.79).

Assume you are standing 9.2′ from an object to be photographed and must use bounce flash because of various circumstances. You are using ISO 400 film, and your camera's sync speed is 1/60th of a second. A direct flash photograph would require an f/22, at 1/2 power, according to the flash LED panel.

When you are aiming the flash to a position on the ceiling midway between yourself and the subject, the distance to the ceiling is 5′. From that point on the ceiling to the subject on the floor is 13′, for a total of 18′ the light of the flash has to travel. The LED panel indicates an f/16 is the appropriate f/stop for an 18′ distance, but that really means an 18′ distance of direct flash, not bounce flash.

So, you open up 2 stops from the recommended f/16 and take the first photograph with an f/8. You then bracket +1 and take another photograph at f/5.6. You may now be wincing. Did the author just recommend to take a photograph with an f/5.6? Yes, and it hurt just touching the keyboard to type "f/5.6." This means a new Rule of Thumb is warranted.

RULE OF THUMB 6.6

When you are using bounce flash, if the subject of the photograph is 9′ or farther from you, you many need to use an f/5.6 or a wider aperture, which will diminish the depth of field. Consider ways to get closer to the subject to avoid having to use wide apertures. Or, consider bumping up the ISO from 400 to 800.

Because of the light loss when using this technique, bounce flash is not recommended for long or large scenes. Bounce flash requires the use of much wider apertures, and the resulting DOF reduction may be too great for large scenes. If faced with this circumstance, consider segmenting the large scene into more manageable smaller ones. This makes more sense than trying to photograph long scenes with wide apertures, knowing that the entire scene will not be in focus. Relatively small areas, however, such as tabletops and most kitchens and bathrooms, can often benefit from the softer diffused light produced with bounce flash.

Fig. 6.80 demonstrates the DOF loss when using wider than normal apertures with bounce flash. During a photography class at GWU, this author determined the proper bounce flash exposure for one of my students. See the pen's shadow under the pen indicating the light is coming from above. That student was properly exposed. As the image



FIGURE 6.80
Image of my class taken with bounce flash.
Thanks to students Eric Spiegel, Justin Labiosa, Shaina Byrnes, and Lesley Grant.

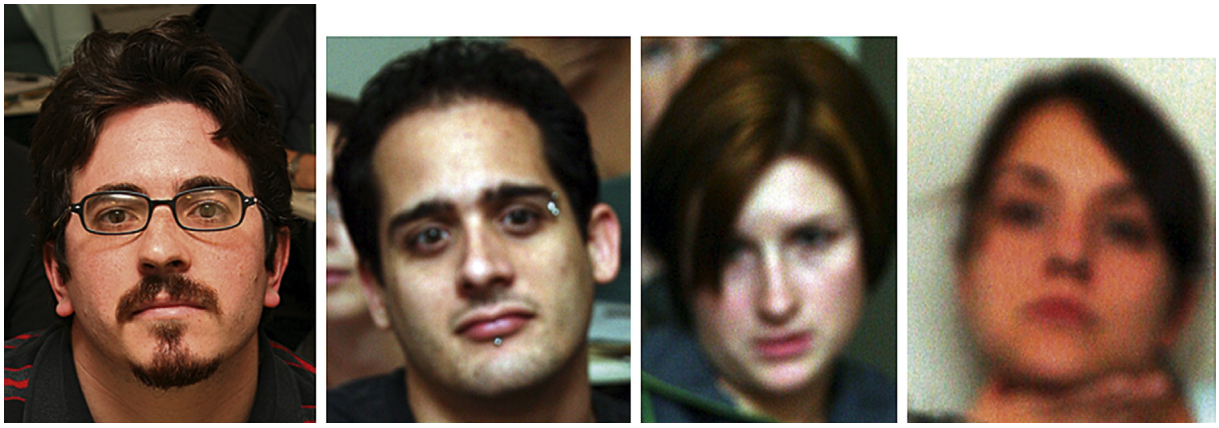


FIGURE 6.81
Progressive depth of field loss when using an f/5.6.
Thanks to students Eric Spiegel, Justin Labiosa, Shaina Byrnes, and Lesley Grant.

was examined more carefully, a noticeable progressive deterioration of the area in focus behind the primary subject was noticed. It was necessary to use an f/5.6 to take the photograph, since the classroom ceiling was so high. Fig. 6.81 shows this loss of focus more clearly. Each student suffers from being more and more out of focus. Remember this! This is the DOF you too will get when using an f/5.6.

PAINTING WITH LIGHT[3]

When to Use Painting With Light

Painting With Light (PWL) is the photographic technique to be used whenever a single flash would be inadequate for the size of a large dimly lit scene. Whereas the flash may indicate an f/2 can light a single object 60′ away, it should not be used for a scene 60′ long because an f/2 will also result in minimal DOF. In addition to outdoor scenes during the night, PWL can also be used in large interior areas, such as parking garages, gymnasiums, theaters, and indoor concert venues.

Many law enforcement agencies have access to light trucks that can bring in auxiliary lights. However, as was stated earlier, it is not just the light volume that is an issue. The proper colors of objects within the scene will only be captured if lit by either midday sunlight or electronic flash. Other lights will usually introduce colored tints into the scene, and at times, these tints will be unpredictable and objectionable. Know that if this happens, one can always print out the image with misleading color tints as digital grayscale images. In these situations, this would certainly avoid the color tint issue. With a digital camera, the white balance adjustment might fail if multiple light sources are used to light a large scene.

The better choice is to use the PWL technique. It allows for the scene to be properly colored, but when practiced so that it can be efficiently done, it is even more convenient than having to wait for light trucks to respond and set up.

Fig. 6.82A shows a scene lit by a single flash, showing how inadequate it is for the size of the scene. The same scene is then lit with the PWL technique. When done properly, it is as if "God turned on the light" so the entire scene could be properly exposed. The PWL technique properly lights a large scene as if it were daylight. Multiple flashes are used to provide balanced light on the sensor, so that the accumulated light is adequate for the size of the scene.

Painting With Light From Two Sides

With a large outdoor nighttime crime/accident scene, PWL provides adequate light to properly expose the entire scene. Basically, PWL entails the camera being mounted on a tripod, and the shutter being opened for as long as it takes to have someone circle the entire scene, firing a hand-held flash unit multiple times to ensure the entire scene receives enough light for a proper exposure.

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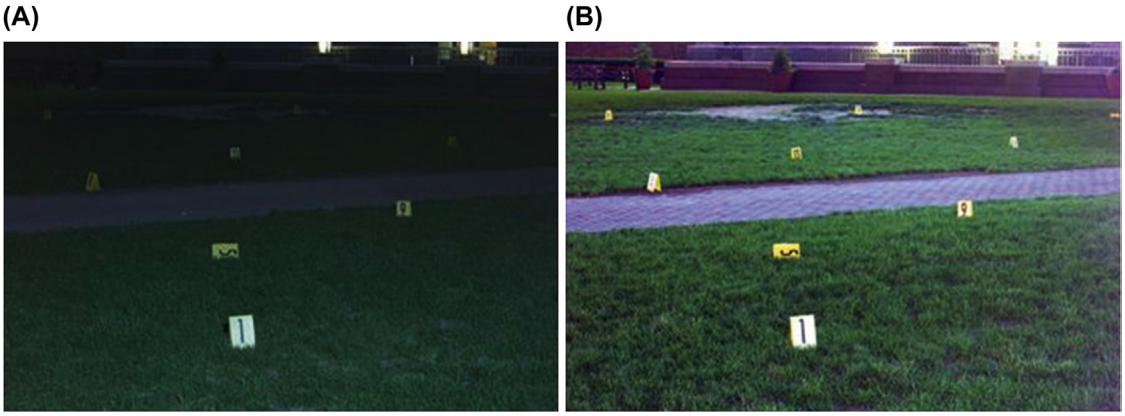


FIGURE 6.82
A large scene lit with a single flash and by painting with light.

Twenty variables have been determined that apply to the basic PWL situation. Perhaps that sounds intimidating. However, once you think about it, because all the variables are described in the following paragraphs, there will be nothing for you to have to "invent" for yourself. All the hard work has been done for you. You now only have to understand the variables and then apply them when the need arises, which is far less intimidating than a challenge from a photography instructor to you to determine all the variables yourself. It is hoped, as the variables are described, your reaction to most of them will be, "Of course, why would it be done any other way?"

The twenty variables seem to logically fit into three areas nicely:

- Tripod variables
- Camera variables
- Flash variables

The variables make perfect sense once they have all been explained. Many are interrelated and will make sense only when their counterparts have been explained. Because of this interrelationship, a sequence cannot be assigned to individual variables that will make them totally understandable as they are presented. Give all these sections a first reading, and when you begin the second reading, you will find yourself nodding in agreement as each variable is explained.

TRIPOD VARIABLES

Assume a large nighttime outdoor crime scene has to be photographed.

1. The first thing that must be done is to establish a viewpoint of the scene. Some scenes would fit beneath a large circle because they are as long as they are wide. Many scenes, however, are wider from one point of view and narrower from another point of view. If this is the case, select the point of view that has the scene arranged so that it is at its narrowest orientation as you view into it. The PWL technique has the virtue of being able to light extremely long scenes; wide scenes will be problematic. It may be necessary to walk around the scene so that this narrow alignment of the evidence can be established. Once this has been done, other variables will make more sense.
2. Now that the viewpoint has been established, the tripod eventually will have to be located somewhere. Set it up approximately 21′ from the closest item of evidence. Many have long strides which are approximately 3′ in length. Stand near the closest item of evidence and take seven giant steps away from it, and set the tripod there. From the tripod to the first item of evidence forms the line that, if continued, has the evidence laid out long (away from the camera) and narrow.
   This variable gets questioned perhaps more than any other. Why 21′? Eventually, you will see that the bottom of the camera's composition will be set to a 15′ distance from the camera. Having the closest item of evidence at 21′ ensures it is near the camera without risking it getting too close to the bottom edge of the photograph to possibly be cut off. Could 18′ have worked just as well? Yes. If you are not happy until you force a concession from everyone you meet, you may select your own distance for this closest item of evidence. Just have it be far enough beyond the 15′ point distance so it does not risk getting cut off.
3. Mount the camera on the tripod. Raise it to your eye height so that viewing the scene through the viewfinder is similar to viewing the scene without a camera; this is called your natural perspective. People viewing your photograph of the scene would see the scene as if they were standing at your side as you viewed it without a camera.

4. The camera will have to be tilted up or down on the tripod some specific angle. When you are determining the tripod location by pacing off 21′ from the nearest item of evidence, after just two paces, 6′ from the evidence, temporarily set down an evidence marker. That marker will now be 15′ from the tripod. While looking through the viewfinder, raise and lower the camera until the bottom edge of the viewfinder aligns with the marker 15′ from the camera. Your view of the scene is now 15′ and beyond. The marker at 15′ can now be picked up.

CAMERA VARIABLES

5. Because it is a dark scene, initially set the camera to ISO 400. Tests have shown that many current digital ISO 800s have excellent resolution and do not suffer from the graininess that ISO 800 films once had. Digital cameras will easily be able to have different ISO equivalents set as desired. Digital noise with ISO 800 settings is generally as low as the digital noise level of ISO 400 settings. You must try photographing the same subject with ISO 400 and ISO 800 to see to what extent this is true for your camera. Digital ISO equivalents of 1600 and faster almost always show progressively increased digital artifacts.
6. Use a 50 mm lens focal length. This photograph is an example of an exterior overall photograph, and the 50 mm lens shows the scene as the eye saw it. Evidence within the scene seems neither nearer nor farther from the camera when viewed through a 50 mm lens. With a digital camera that has a focal length multiplier, the "normal" lens for your camera may be something like 31–33 mm.
   Using a "normal" lens is also the reason you want to establish a view of the evidence so that it is laid out narrow rather than wide. The "normal" lens can encompass a view of just 36–46 degrees of the real world. Were the scene aligned so the evidence was wide, rather than narrow, the use of a "normal" lens would force you to back away from the evidence to include it all in your composition. Because the evidence is now viewed so it falls into a relatively narrow alignment, you can get closer to the first items of evidence.
7. A camera exposure mode must be selected. Choose the manual exposure mode so that you can select a specific shutter speed and a specific f/stop.
8. Set the camera to its "bulb" shutter speed, which is the shutter speed that has the shutter remain open for as long as the shutter button is depressed. Because the shutter has to be open for a long time, also use a remote shutter release cable that is capable of locking the shutter open. This can be a manual remote shutter release cable that screws into a hole in the shutter button, or it can be an electronic shutter release cable. Some other cameras have a shutter setting that will lock the shutter open the first time the shutter is depressed and then close the shutter the second time the shutter is depressed. This will also work. Long exposure times can also produce digital artifacts. The PWL scenario can typically take 20 s or longer, and the digital sensor is not optimized for long exposure times. Combined with high ISO equivalents, the digital noise can become quite problematic with some digital cameras.
9. The f/stop selection will be based on half the width of the back of the scene. While you are looking through the viewfinder, have an assistant walk to the back center of the scene, at the distance from the camera of the last item of evidence. Establish an imaginary line between the center of the back of the scene and the camera. Perpendicular to this line, have the assistant begin walking away from the center of the scene until he or she just barely steps out of your field of view as you view the scene through the viewfinder. Yell "Stop" to your assistant when he or she steps outside the camera's viewpoint. Have the assistant place a marker at this location. Repeat this procedure on the other side of the scene and have a marker placed there also. Both markers should be just out of the field of view of the viewfinder. Have your assistant pace the distance between the two markers or measure this distance with a tape measure. If your assistant's pace is also approximately a 3′ stride, multiply the number of paces by 3 to determine the width of the back of the scene. Divide the total width of the back of the scene by 2. An assistant will eventually hold a flash unit at each marker location, aimed toward the center of the scene. It will only be necessary for each flash unit to light just half the width of the scene. For example, if the total width of the back of the scene is 60′, half of that is 30′. Each of the multiple flash firings will have to light a 30′ long area. The flash in the manual flash exposure mode will indicate the f/stop necessary for this distance.
10. Now that the f/stop has been determined, it will be possible to focus the camera by the hyperfocal focusing technique. Recall that,
    - f/22 had a DOF range of 6′ to ∞ when focused at 12′;
    - f/16 had a DOF range of 8′ to ∞ when focused at 16′;
    - f/11 had a DOF range of 12′ to ∞ when focused at 24′;
    - f/8 had a DOF range of 15′ to ∞ when focused at 30′.

Of course, this presumes a flash with a GN of 120. Should you be using a flash with a different GN, your own calculations will have to be determined.

In this hypothetical case with a 60′ wide scene, the flash will have to light 30′. With a 120 GN flash, the f/stop to light a 30′ distance is an f/8, according to the flash. To hyperfocal focus with an f/8, focus on something 30′ away from the camera. If your lens has a distance scale, just align the 30′ distance over the focus point. Without a distance scale, have an assistant stand 30′ from the camera with a flashlight held to light his or her face and focus on the face.

This will change with the width of the back of each scene. However, for some reason, most times this author had to use the PWL technique to light the scene, f/8 turned out to be the most frequently used f/stop.

11. If the crime scene is in an area with the ambient lights of buildings located behind the camera, or if roads are nearby where cars can swing around and ultimately hit the back of the camera with their headlights, then the camera's viewfinder will eventually have to be covered. Extra light coming into the camera through the viewfinder can ruin a PWL photograph. Many, if not most, cameras have a viewfinder cover for this very purpose. If your camera does not have a viewfinder cover, throw a roll of black electric tape into your camera bag, and just before the flashes begin lighting the scene, cover the viewfinder with black tape.

FLASH VARIABLES

12. Use a 120 GN flash. The settings for this hypothetical case are based on the use of a 120 GN flash. A weaker flash will necessitate the use of wider apertures, which will negatively affect the DOF range. You can use a flash with a stronger GN, of course, because it would ensure smaller apertures are used for the same sized scenes, thereby ensuring an even better DOF is obtained.
13. The flash exposure mode should be set to manual. This large dimly lit scene requires all the light the flash is capable of. The benefits of the automatic or dedicated flash modes revolve around their ability to cut off the flash power early, which is not applicable in this situation.
14. Because a "normal" lens is being used, the flash head must also be set to "normal." The flash head will be used detached from the camera's hot-shoe, so this will have to be done manually. The camera cannot "tell" the flash which focal length of lens is being used. When you are using a digital camera with a focal length multiplier, even though your "normal" focal length may be 33 mm, you should set the flash head to 50 mm because that is the scene now composed in the viewfinder. One should not use either wide angle or telephoto focal lengths for painting with light. Recall that the wide angle focal lengths would tend to elongate the foreground to background distance, and the telephoto focal lengths would tend to compress the foreground to background distance.
15. Markers have already been placed where the flash operator can stand safely and not be in the field of view. In this case, the "safe spots" are 30′ from the middle of the crime scene. It is important that the flash not be in the field of view when it is fired. If there has been a miscalculation about the "safe spot" for the flash, and the camera can "see" the flash go off, the results are interesting but not conducive to a successful photograph. If the camera can "see" the flash pop, the result is a variation of the Star of Bethlehem.

    Fig. 6.83 shows the PWL setup, except the focal length of the lens was intentionally widened to include the two markers that would have been "safe spots" had a "normal" lens been used. Now, three flash bursts can be seen: one at the left rear and two at the right rear. The flash bursts do not contribute to the success of the final image. Fig. 6.84 shows what many would imagine the true Star of Bethlehem would look like. Interesting? Yes. A beneficial addition to the photograph? No.

    From these flash positions at the rear of the scene, the flash operator needs to work around the scene until it is completely lit. When doing so, the flash operator must remain 30′ from the imaginary midline of the crime scene. The best way to ensure the flash operator does not accidentally begin to get closer to this imaginary midline is to place two more markers 30′ from the camera's position: one on the left and one on the right. Then, the flash operator continues on a line from the marker at the rear of the scene to the marker opposite the camera's position.
16. The flash operator will be manually firing the flash by pushing the appropriate button on the flash. The flash, however, is in full manual mode and, with the camera set at f/8, will light a distance of 30′. If the flash is just held at chest height, it may overexpose the area nearest the flash operator. To help prevent this overexposure possibility, the flash operator holds the flash at arm's length directly above their head. This will help prevent burning out the scene just beyond the flash operator's position.
17. Now that the flash is as high as the flash operator can get it, where should it be aimed? The first inclination is to aim the flash at the midpoint of the scene. However, the midpoint will actually receive some light from both sides of the scene. Because of this, to avoid overexposing the midline, it is suggested to aim the flash so it strikes a point about 4/5th of the way into the midline. Then, the midline overlaps of light will blend well.



FIGURE 6.83
Painting with light: intentional use of wide-angle lens to show the "safe spot" markers and flash bursts.



FIGURE 6.84
Painting with light: "Star of Bethlehem" visible in left rear.

This is easier said than done and is one of the critical aspects of the PWL technique. Should the flash operator accidentally hold the flash so it projects its light parallel to the ground, or worse yet, above the scene, the scene will be very underexposed. It is essential that the flash be aimed slightly down from its position held above his head. When you are standing directly under the flash head, it is very hard to determine the angle it is aimed into the scene. For this reason, it is recommended that the flash operator stand to either side of the flash unit.

Fig. 6.85 shows how the angle of the flash head can be determined when standing at either side of the flash. From beneath or from behind the flash unit, the angle it is aimed into the scene cannot be determined.



Aimed too high | Aimed parallel | Aimed down: correct



From underneath, the angle is impossible to determine

FIGURE 6.85
Painting with light: flash angles into the scene.

18. Once the first flash has been fired, the flash operator must walk to a new position to fire it again. As mentioned previously, the flash operator should walk toward the marker 30′ from the camera position. Because the flash throws light out in the shape of a bubble, it will be necessary to go to a position that will enable the sides of the flash bubbles to overlap so no gaps are present in the overall lighting. From trial and error, it has been determined the correct distance to walk to arrive at this new position is "five casual paces." Not giant steps! Not baby steps! Walk five of your normal paces down the line. Photographers are short-legged and long-legged. When tall and short people walk alongside each other with "normal paces," they will stay together without much effort. During this five-step walk, the flash usually will have a chance to recharge and be ready to fire again, if not immediately, very shortly thereafter.
This five-step interval between flashes into the scene only needs to continue until the area 15′ from the camera has been lit. Remember, the first 15′ between the camera and the scene will not be in the field of view and, therefore, does not need to be lit.
Walking around the camera's position to get to the opposite side of the scene provides the flash operator the perfect opportunity to fire one flash into the scene from the camera's position. Lighting the scene from both sides does not light the front of the evidence close to the camera. The scene looks more normal if the closer items of evidence get some front lighting. This flash does not overexpose the front of the scene at all. Just remember to aim the flash so it will strike the ground about 21′ from the camera.
Beginning at the point 15′ from the camera, a series of flashes are then popped into the scene from the opposite side as the first flashes. Each side will get five to eight flashes, and one flash will come from the camera's position.
Coordination between the camera operator and the flash operator:

19a. To get ready for the actual photograph, the camera operator will cover the viewfinder with the viewfinder cover. They will hold up a piece of black construction paper/cardboard over the end of the lens, trip the shutter with the shutter release cable, and lock it open. They will then await the flash operator's signal that the flash has charged and they are in position. Fig. 6.86 shows the camera operator awaiting this signal.

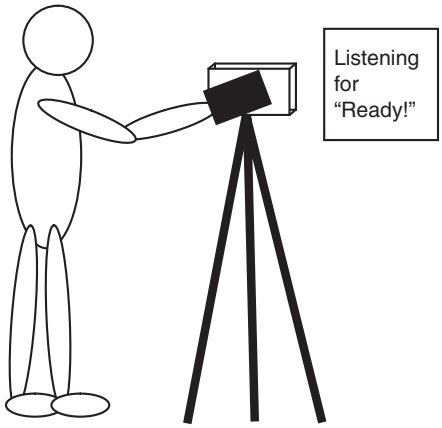


FIGURE 6.86
Camera operator’s position waiting for “Ready.”

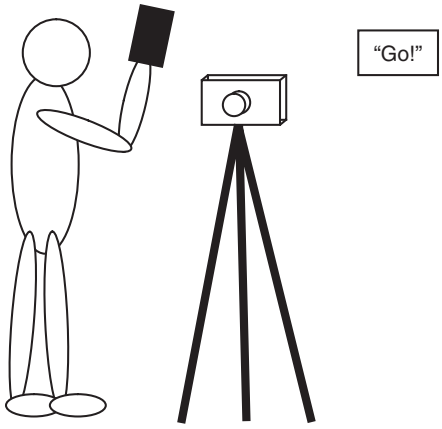


FIGURE 6.87
Camera operator’s position for “Go.”

In this position, it is critical that the camera operator concentrates on the position of the black paper/cardboard and the lens. It is imperative that the tripod not be moved and that the paper not strikes the lens and moves the camera. Doing either will introduce an offset into the sequential exposures on the sensor, which will look like blur and ruin the image. The camera operator will be able to see when the flash goes off with their peripheral vision; it is not necessary for the camera operator to be looking down into the scene. Their entire job is to cover and uncover the lens during the flashes without bumping either the camera or tripod.

19b. When the flash operator notices the flash has fully charged, it is held overhead, aimed to strike the ground about 4/5 of the distance into the midline, and they position their finger over the manual flash button. They then **yell**, “Ready!” This is not a polite whisper or said in normal conversational tones. The flash operator may be 60′ or so from the camera operator, and there may be ambient noise in the area.

20. On hearing the flash operator **yell** “Ready,” the camera operator raises the black paper away from the lens, and when it reaches the apex of a 90-degree rotation, the camera operator **yells**, “Go!” (see Fig. 6.87). This is not a polite whisper. It is not said in a conversational tone. There may be distracting ambient noise in the area. The camera operator **yells** “Go” when the black card has reached the top of the arm swing. Without waiting for the flash to go off, the camera operator immediately swings the black paper back to a position in front of the lens. If the flash operator did not get the flash to go off in that brief time period, the process will have to be repeated. After all, why would the flash operator have said “Ready!” if they were not ready?

This process is repeated as the flash goes off multiple times from one side, once from the camera position, and then from multiple positions from the other side. When all the flashes have been fired, the shutter release cable is unlocked, the shutter closed, and the black paper can be removed from in front of the lens.

PAINTING WITH LIGHT TIPS

1. It was mentioned that black construction paper/cardboard be used to cover the lens during the PWL technique. When black construction paper/cardboard cannot be found, a hat or clipboard can be used instead. If the clipboard is light colored, however, it should not be used. If it is glossy or will reflect light striking it into the lens, it should not be used. The key here is to use a dark, opaque, matte object to cover the lens to prevent stray light entering the camera between flashes. Black construction paper is ideally suited for this job. Put some in your camera bag.
2. The manual flash mode eats batteries. Do not attempt this process with used batteries in the flash unit. It is very frustrating to have pedestrians and traffic stopped from entering the scene, have support personnel staking out the perimeter to prevent strays from entering the scene from various directions, and then have to wait for used batteries to charge the flash between flash cycles. Put new batteries into the flash unit before attempting the PWL technique.
3. Better yet, use two flash units, both with new batteries. Two people are acting as camera and flash operators, and often that means two camera kits are available. When the flash operator has two flashes, both with new batteries, the actual process of PWL can be just a few minutes long. With two flash units, the flash operator can walk around a large scene hardly needing to stop at all because they keep alternating from one flash to the other so one is always ready to go. Both flash units, of course, have to have the same GN.
4. It would be possible for multiple flash operators to stand around the scene and pop off multiple flash units with one "ready/go" sequence and then all move to another position. This can be tricky if one of them does not notice that one or the other flash units did not fire in the proper time frame. Unlit gaps in the scene will be the result. If the use of multiple flash operators is considered, it is also imperative to ensure all the flash units have the same GN. If not, there can be a noticeable difference in flash bubbles.

Fig. 6.88 shows most of the PWL process. A "normal" lens encloses eight items of evidence in its field of view. "Safe spots" for the flash operators have been determined, and multiple flash bursts come from the same

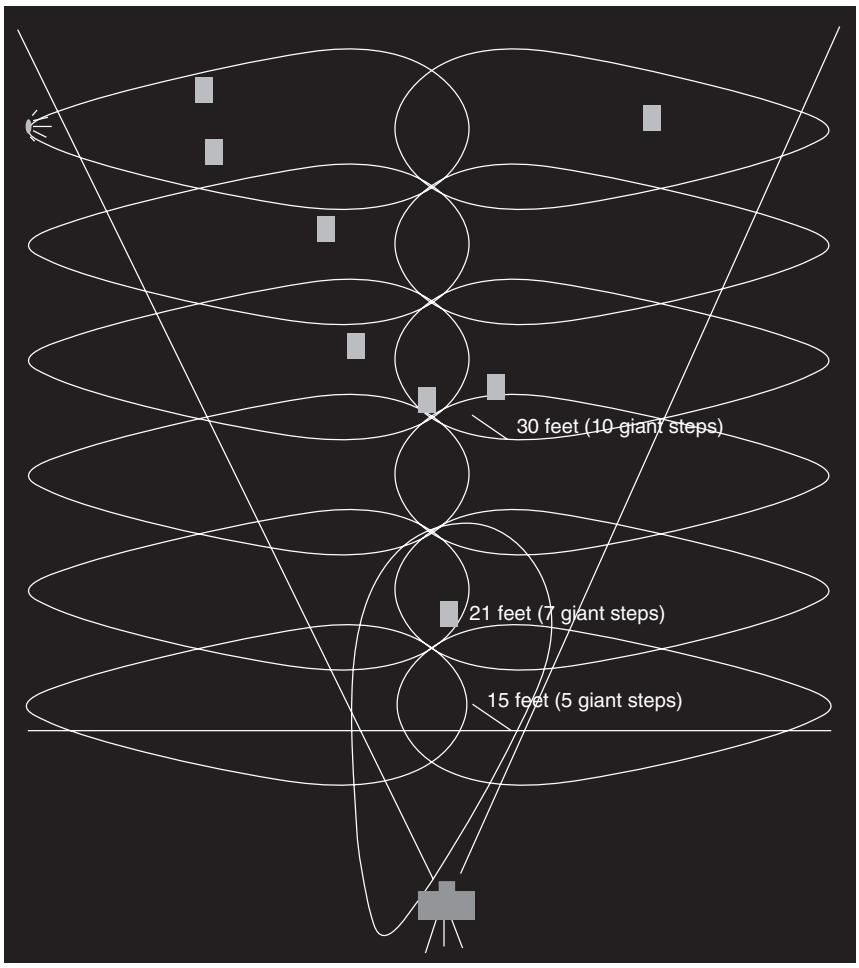


FIGURE 6.88
The painting with light process with multiple flashes.

distance from the midline. Flash bursts overlap in the middle of the scene and between adjacent bursts. One flash is directed into the scene from the camera's position. A line at 15′ represents the bottom of the camera's composition as it is tilted on the tripod. The first item of evidence is 21′ from the camera. "A-frame' markers have been laid on their sides at the 15′ and 30′ points: at 15′ for the camera tilt and at 30′ for hyperfocal focusing. Both of these will be picked up before the shooting begins.

5. The PWL technique can be done with only one person if it is dark enough to leave the shutter open without being blocked between flashes. Then, a single person can run around the perimeter of the scene firing off the required number of flashes.
6. At times, there will be a relatively large item in the crime scene, on one side or the other of the scene (like a car). If it were in the middle of the scene, it would be easy to get the prescribed distance from it with the flash so it would be properly exposed. When the object is on the side of the scene, the side visible to the camera is too far away from the flash operator on the opposite side of the scene for a normal flash burst to fully illuminate it. Because it will be captured by the camera, you will want it properly exposed.

The trick is to turn your flash operator into a "snowflake." Recall how falling snow can be eliminated from an image by determining an exposure for a 2-s shutter speed? Because the snowflakes are never in the same spot long enough to be properly exposed, they are blurred sufficiently so they seem to disappear. It may be necessary to have the flash operator walk into the scene to properly expose the side of the object toward the midline of the scene. If you just ensure the flash operator keeps moving and is never directly lit by any direct light source, the operator may not appear in the photograph.

This solution, however, creates new problems. If the flash operator walks into the crime scene area holding the flash unit above his or her head, the flash burst will be recorded on the image even if the flash operator is not. Correct. So the flash operator must bring down the flash unit so that his or her body blocks the flash from being seen by the camera when the flash goes off. This, however, gets the flash, strong enough to light a distance of 30′, close to the ground where it will likely overexpose the area near the flash. This necessitates a manual flash intensity reduction. The flash LED indicates f/8 is proper for 30′ at full manual power, f/8 is proper for 20′ at ½ power, and f/8 is proper for 15′ at ¼ power. It is recommended to use the ¼ power setting and be 15′ away from the object of interest when the flash is fired. Trying to light an object the size of a car with a flash head set to "normal" from just 15′ may not light the full width of the car. Change the flash head to "wide" angle to force the light wider than normal. True, this may diminish the flash output straight ahead somewhat, but you can live with that. Remember, the side of the car closest to the midline did receive some light from the flashes on the opposite side of the scene but not enough for a proper exposure. Having the flash held by the flash operator slightly dimmer will augment this other light nicely.

Fig. 6.89 demonstrates the movement of the flash operator. Without ever stopping, when the operator approaches the 15′ distance from the car, he or she yells, "Ready," the camera operator yells, "Go," and the flash is popped. Continuing across the scene, the flash operator exits stage left. Many examples of this technique have been successful. There can be no bright ambient light around the scene to light the flash operator. It is also critical that the flash operator light the car from the side, and that he or she avoids lighting the rear of the scene with the flash burst. If this is done, the flash operator may be noticed as a dark silhouette.

The flash operator should be wearing dark clothing if you want him or her to "disappear" from the scene. Light clothing may reflect some stray ambient light into the camera.

Fig. 6.90 is an actual image trying to duplicate the graphic in Fig. 6.89. The charlie-horse is positioned like the rectangle in Fig. 6.89. There are two things to point out. Why does there appear to be a bright light covering the #7 marker? This is where a flash, held by someone walking through the scene, also lit the ground when it was aimed at the charlie-horse. The flash should have been held more parallel to the ground so it could not be noticed like it is. And, just where was the flash operator standing when this happened? Part of them is still showing! From the #5 marker, move your eyes about 2′–3′ to the right, and then up a bit. See what looks like a partially transparent white arm? My best guess is that light from the flash struck the charlie-horse and the sign on it, and these acted like a bounce card and lit the arm covered in light-toned fabric on the side facing the charlie-horse.

If the midline side of a large object in the crime scene needs to be lit, it is suggested that this flash be the first one. All the other flashes from around the scene perimeter should follow this flash burst. The darker the scene, the easier for the flash operator wearing dark clothing to become invisible.

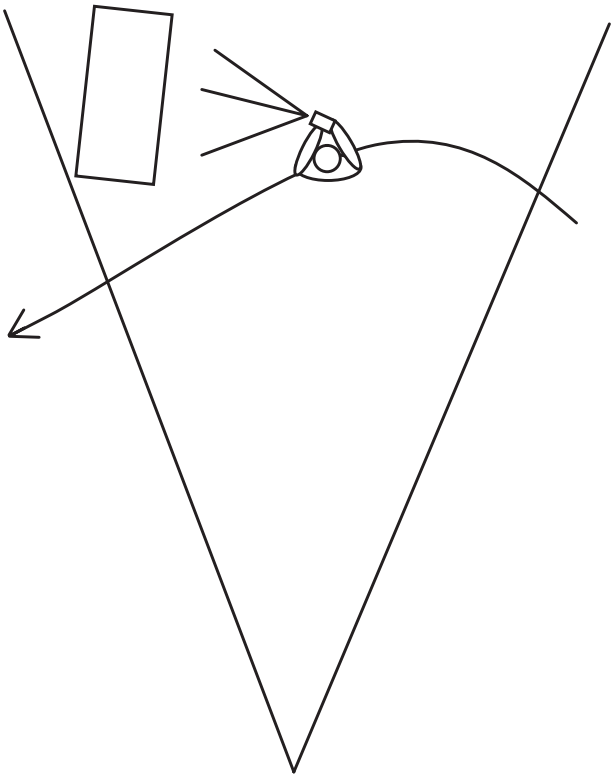


FIGURE 6.89
Painting with light graphic: flash operator turned into a snowflake.



FIGURE 6.90
A photo example of Fig. 6.89.



FIGURE 6.91
Top lit by a single flash; bottom lit with painting with light technique.

Fig. 6.91 shows two images. The top one was lit with just one flash burst from the photographer's position. The bottom was done with the 20 PWL steps described above. During the time it took to encircle this scene firing multiple flashes, the far background reflected light each time the lens was uncovered. Makes one wonder if this works for the far background, why cannot this be applied to the foreground as well?

Stand by for more on this.

Painting With Light From One Side

Sometimes it is impossible to flash into the scene from two sides. A riverbank or cliff may be on one of the sides of the scene, or a building façade may be on one side of the scene. Many things can prevent a flash operator from getting to both sides of a scene. In these cases, only a slight modification of the PWL technique as already explained is required to deal with these possibilities.

Imagine the vertical line on the far right side of Fig. 6.92 to be a building façade, cliff, or riverbank. In this situation, the flash operator can stand only on the left side of the scene. It will now be necessary for multiple flashes, all on the left side of the scene, to light the full width of the scene. With a 120 GN flash unit, and a 400 ISO, these will be the choices:

- f/22 can light 10′;
- f/16 can light 15′;
- f/11 can light 20′;
- f/8 can light 30′;
- f/5.6 can light 40′.

If you bump up the ISO to 800, these will be the choices:

- f/22 can light 15′;
- f/16 can light 20′;
- f/11 can light 30′;
- f/8 can light 40′;
- f/5.6 can light 60′.

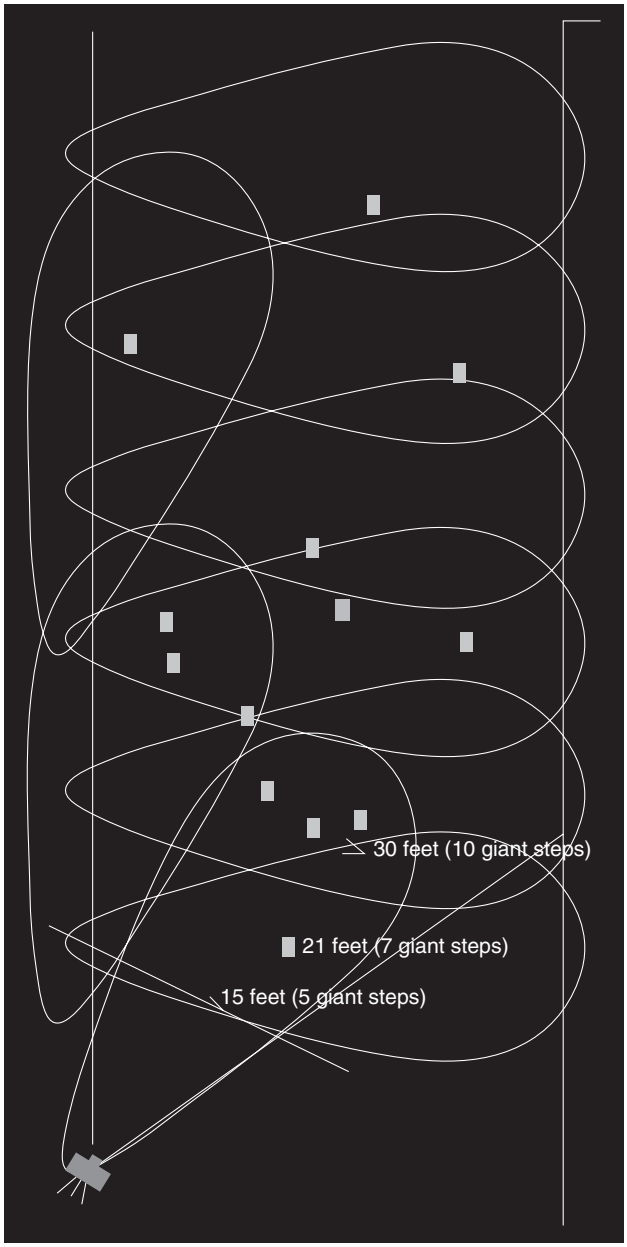


FIGURE 6.92
Graphic of the painting with light technique done from one side.

First, determine the distance from the wall/river/cliff where the farthest item of evidence is located; this is the width of the crime scene that will have to be properly exposed. That will decide the necessary f/stop. It will be necessary to light the wall and this item of evidence with a flash. For this hypothetical exercise, presume the item farthest from the wall is 28′ away. This means that an f/8, with an ISO of 400, will adequately light the scene 30′ wide.

Establish a point that is 30′ from the wall by pacing the distance or using a tape measure. Place a marker just outside this distance at about 30.5′. At the other end of the scene, place another marker at the same distance. This will establish the "safe" line. Flash operators can stand just behind this line, and they will not appear in the photograph.

The camera on a tripod can be placed so the camera is 30′ from the wall. Now the camera on the tripod can be rotated to the left or right so that either the right side of the field of view or the left side of the field of view aligns with an imaginary line 30′ from and parallel to the building façade/river bank/cliff. Notice, in the case of the graphic that the left side of the field of view, as seen through the camera viewfinder, has been positioned to be parallel to and 30′ from the building façade. The camera on the tripod can be moved along this imaginary line 30′ from the wall to a point at which the tripod is also 21′ from the closest item of evidence. Sound familiar?

The camera is tilted so that the bottom of the viewfinder hits the 15′ location. An item 30′ from the camera is focused on to hyperfocal focus. Now, everything from 15′ to infinity will be in focus.

Nine different flashes were needed to completely cover this scene. Six were directed into the scene from the "safe" line, one was aimed into the scene from the camera's position, and two more were aimed along the "safe" line. Notice that the flashes on the line 30′ from the wall created flash bubble gaps that had to be covered by the second line of flashes that are aimed down the "safe" line. If this is not done, a zigzag of dark unexposed triangles will be seen at the left side of the image.

Fig. 6.93 shows an example of PWL from one side created as part of a training exercise at a local police academy. In this case, the "safe" line was a sidewalk on the right side of the image that was parallel to the building wall.

The PWL technique certainly works well once it has been practiced a bit. Other agencies may prefer to use either of two alternate lighting techniques for a large dimly lit scene: time exposures and taking the photographs with the aperture priority technique. Although these techniques will also be explained in chapter "Special Photography Situations", under the discussion of traffic accident photography, they will also be covered here for your convenience.

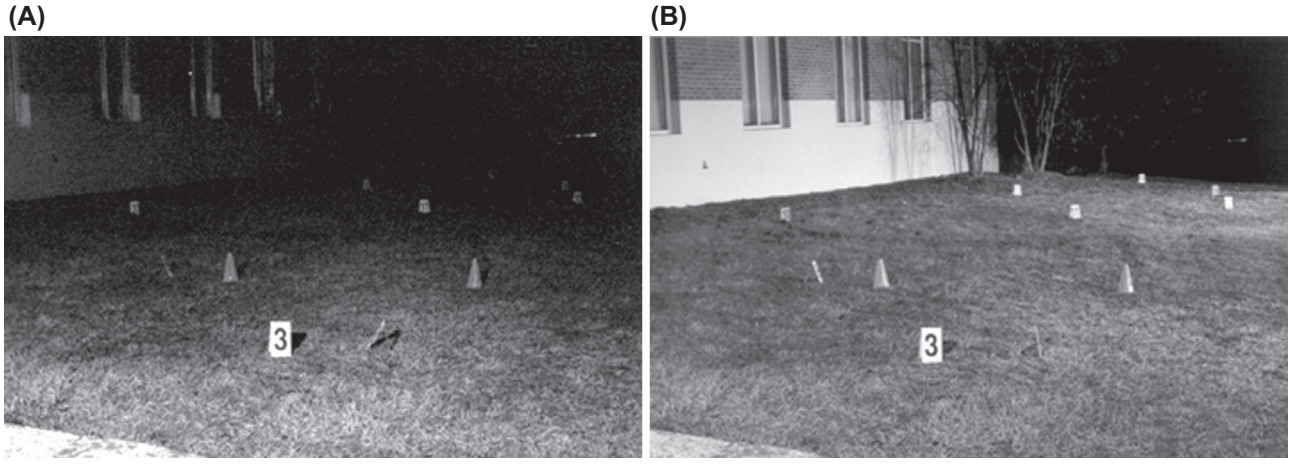


FIGURE 6.93
(A) A single flash. (B) Painting with light from one side.

Fig. 6.94 is an example of three different time exposures. Because the scene is predominantly lit with nearby building lights, we must be prepared for color tints which are not normal. For this reason, I have converted each image into its grayscale equivalent, so we can just concentrate on the exposures. It was 10 pm, and very dark, except for the building lights. The reason for the three time increments is that this was done when film cameras were the norm, and experience told us one of these exposures was usually adequate for our purposes.



FIGURE 6.94
Time exposures.

Fig. 6.95 shows a comparison between the standard PWL technique and a time exposure. Again, these are presented in their original colors and in gray scale. Many felt the true colors of the PWL technique trumped a larger area of exposure from the time exposure. We felt only areas outside the scene of interest were also lit well with the time exposure. Had we needed a longer or wider area with proper colors, we could have done that with the PWL technique.

I may just be this author's opinion, but it seems that more and more agencies today are opting for images captured with the aperture priority technique than with either time exposures or PWL. With this technique, the camera is mounted on a tripod, the aperture priority exposure mode is selected, the ISO is set to 400 or 800, and the aperture is set for f/8 and then hyperfocal focused. This results in everything from 15′ to infinity being in focus with the 400 ISO and 12′ to infinity with 800 ISO. When the shutter button is depressed, the shutter stays open long enough for the camera to gather sufficient light for a proper exposure. It is a very fast process, usually not taking more than a minute or so, depending on the lighting. With our digital cameras, and the ability to tweak any of the exposure variables needed once the first image is captured, the results are frequently quite stunning. Fig. 6.96 is an example, showing the

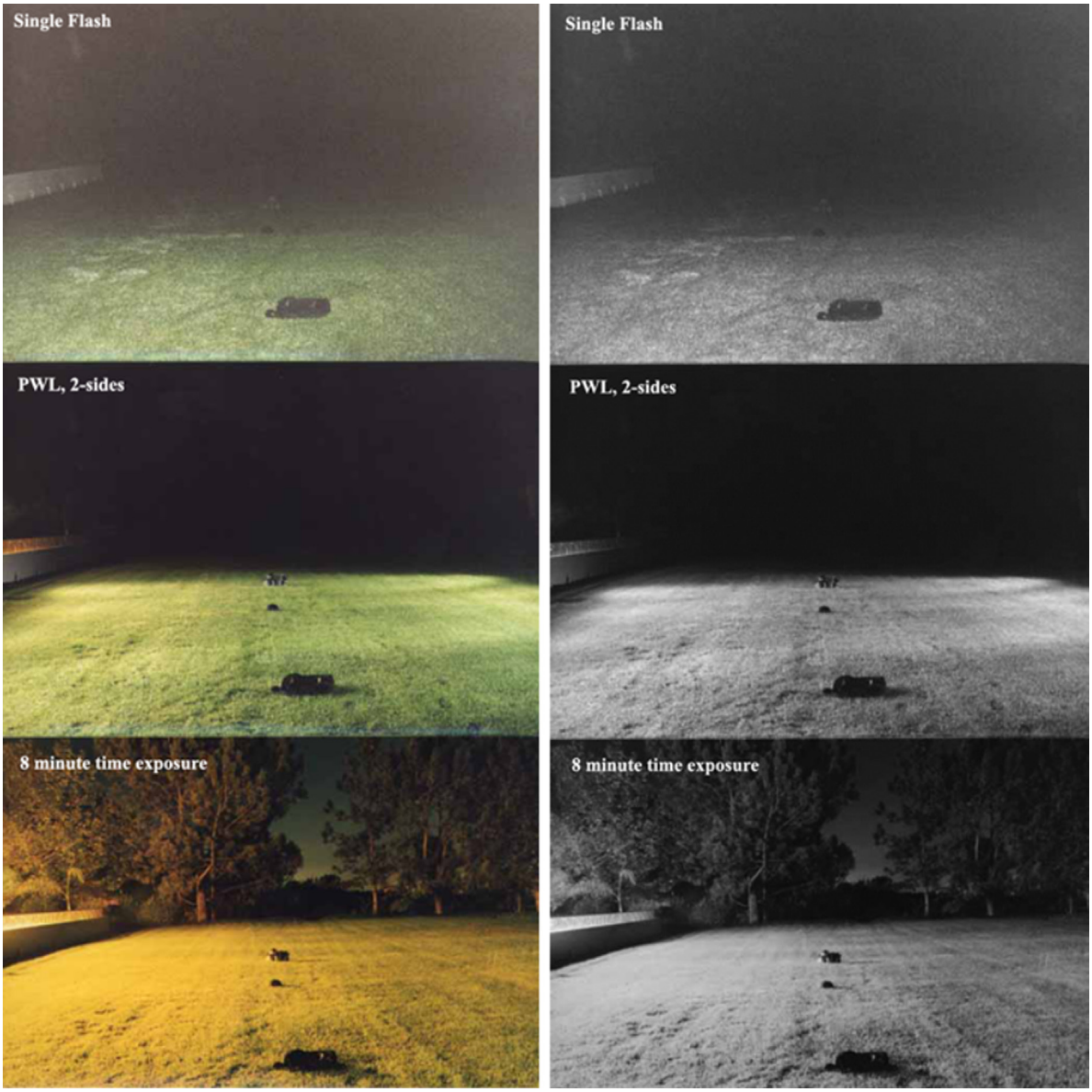


FIGURE 6.95
Painting with light compared to time exposures.

original colors as captured and a grayscale version of it. The grayscale image did have its exposure lightened just a bit in Photoshop. A "normal" focal length was used along with 800 ISO and f/8. The image took 6 s.

If you have not tried this technique yet, try it tonight!

Before this chapter on flash concludes, and now that the PWL technique has been discussed, it is a good time to discuss a potential problem that will occasionally occur when doing flash photography. Imagine the need to photograph shoe prints in dirt at midnight. When you open your camera bag, you find the PC or remote flash cord is either missing or defective. If it is impractical to call for another cord, or none is available, how can you proceed with your photography?



FIGURE 6.96
Aperture priority mode.
Courtesy of GWU MS student K. Caulfield.

One solution may be to use a flashlight as your light source. Take a meter reading of the flashlight beam as it lights the shoe print in the manual exposure mode with the f/stop set to f/11. The meter reading will suggest the appropriate shutter speed. Because the camera will be on the tripod, slow shutter speeds are okay. Just remember to keep the flashlight moving to avoid the flashlight streaky look. Or, you can set the camera to aperture priority, using an f/11, and the camera will automatically select the shutter speed for the proper exposure. The only problem is you would still need to fire your flash because the oblique light of the flash is required to light the 3-D aspects of the shoe print.

Another solution would be to use the flash off-camera without a PC cord, and then set the shutter speed to 2 s and set a 10-s delayed shutter. After the shutter is depressed, you will have 10 s to get into position with the flash. When the shutter opens, manually fire the flash during the 2 s the shutter will be open. As long as no strong ambient lights are in the area, having the shutter open for 2 s will not lead to overexposure.

LEARNING OBJECTIVES, REVISITED

An electronic flash is designated by its GN, a method of rating the relative strength of the flash unit. Ensuring the flash output matched both the camera viewpoint and the focal length of the lens was emphasized.

Many flash units allow the crime scene photographer to choose from the manual, automatic, or dedicated flash exposure modes. These flash exposure modes were explained, along with their relative strengths and weaknesses.

The need to use the camera's designated sync shutter speed was explained.

The various techniques by which a crime scene photographer can control the flash output were also explained. The more controls that any photographer has at his or her disposal, the more precision that can be expected in the final product: a well-exposed photograph. Some techniques may work under certain circumstances, and others may work better in other conditions.

The use of the **Flash Calculator Dial**/LED panel to determine the proper f/stop for the flash-to-subject distance was explained. The ISL, as the foundation for determining the proper exposure when using electronic flash, was explained. The common exposure errors that may be encountered were pointed out.

Bracketing with flash was also explained.

When wide extremes of light are in the scene, ranging from extremely bright areas to very dark areas, the sensor, by itself, will not be able to capture details in both of these extremes. Details will be lost either in the highlight areas or in the shadow areas. Some areas will be either overexposed or badly underexposed. Rather than lose potentially important information in either area, you can use fill-in flash to ensure details in both exposure extremes are captured.

Certain types of evidence are best lit with the light coming from the side. Whenever 3-D texture, pattern, and similar details are present, side/oblique lighting often improves the visibility of these qualities. This chapter explained how to photograph such objects. Reflectors can also be used to soften the hard shadows cast by oblique flash and illuminate evidence hidden in the shadow area.

The benefits of bounce flash and ways to use this technique were explained.

Finally, the PWL technique was explained. The ways to use this technique with the flash directed in toward the scene from two sides and from only one side were explained. Variations on this idea, using time exposures and the aperture priority technique, were also explained.

DISCUSSION QUESTIONS

1. Explain the meaning of flash guide numbers. How can it be determined which guide numbers of flashes are best suited for crime scene work?
2. Is there just one sync speed a camera can use with a particular flash unit? Although most cameras designate one shutter speed as that camera's sync speed, can "faster" or "slower" shutter speeds ever be used effectively at crime scenes?
3. Discuss the nuances of the manual flash exposure mode, including the presupposition that the flash is used in a "normal" room and the flash is used as direct flash rather than bounce or oblique flash.
4. Indicate one circumstance when it would be better to choose the manual flash mode over either the automatic or dedicated flash mode. Why?

5. Indicate one circumstance when it would be better to choose the automatic flash mode over either the manual or dedicated flash mode. Why?
6. Indicate one circumstance when it would be better to choose the dedicated flash mode over either the manual or automatic flash mode. Why?
7. In what circumstances does fill-in flash result in distinct benefits to exposure?
8. Explain all the concerns related to tire track photography.
9. Bounce flash produces dim light on the subject. Explain why this is so and the method to determine a proper exposure when using bounce flash.
10. Explain the differences between the PWL technique from one side and the PWL technique from two sides.

EXERCISES

1. Take a flash picture of any object 15′ from the camera using the camera's sync shutter speed. If your camera will allow it, photograph the same object, from the same position, at 1 stop faster than sync and at 2 stops faster than sync. If your camera allows these shots, you should be able to anticipate the effects of all three different shutter speeds.
2. With the flash mounted on the hot-shoe, take a photograph of any object 10′ from the camera. Keep the flash on the hot-shoe and repeat at distances of 5′, 4′, and 3′. At what distance is it imperative to remove the flash from the hot-shoe for your equipment?
3. Standing 15′ from a white (or, just slightly off-white) wall, determine a proper exposure for the manual flash exposure mode, and take the picture. Using either automatic or dedicated flash exposure modes, from the same position, photograph the same wall without making any exposure compensations. For the third shot, in either the automatic or dedicated flash exposure mode, make an exposure compensation to ensure the wall is not underexposed.
4. Fill the frame with a large black or deep navy blue object (do not use the black or blue painted sheet metal of a car). First, photograph with the manual flash mode. Second, use either the automatic or dedicated flash mode without any exposure compensations. Third, use either the automatic or dedicated flash mode with an exposure compensation to prevent overexposures.
5. On a day with bright sunlight producing deep shadows (an f/16 kind of day), place an object under a car by one of the tires so it is in deep shadow. Meter the sunny part of the scene, set the camera for that exposure, and photograph the object. Next, determine the correct fill-in flash exposure for the same object from the same position. Take that photograph also and compare it to the first.
6. Sometime after 10 pm, find or create a shoe print in dirt, place the camera on a tripod, and photograph it with the flash as directly as possible. Next, determine a proper oblique flash exposure, and take a second image. Compare the two.
7. In a bathroom, place several items around the sink and take a direct flash photograph. Next, determine the correct bounce flash exposure for the same scene, from the same position, and take a second photograph. Compare.

Compare your images with those in this chapter and with other images on the Companion Website (http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646), referring particularly to the following image folders: bite marks, bounce flash, dirt, dust prints, fill flash, indented writing, manual flash, and sync.

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CHAPTER 7

Ultraviolet, Infrared, and Fluorescence

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Key Terms
Electromagnetic Spectrum
Fluorescence
Infrared Light
Luminescence
Phosphorescence
Photographic Infrared Range
Reflected Ultraviolet Imaging System (RUVIS)
Ultraviolet Light
Visible Light

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the various results of light striking different surfaces;
2. Explain where on the EMS the UV range is located;
3. Explain various uses of UV light to visualize otherwise "invisible" evidence;
4. Explain where on the EMS the **Visible Light** range is located;
5. Explain the Stokes shift;
6. Explain some of the different types of evidence that can be made to fluoresce so they can more easily be located and collected;
7. Explain where on the EMS the IR wavelengths are located;
8. Explain several types of evidence that can be visualized in the IR range of the EMS.

THE ELECTROMAGNETIC SPECTRUM

Fig. 7.1 shows the typical wavelength design. The wavelengths of **Ultraviolet (UV)**, **Visible Light**, and infrared (IR) light are expressed in terms of nanometers (1 nm = one billionth of a meter from peak to peak).

Light on the Electromagnetic Spectrum

Other forms of radiation on the **Electromagnetic Spectrum (EMS)** include those with much shorter wavelengths (gamma rays and X-rays), as well as those with much longer wavelengths (microwave and radio waves).

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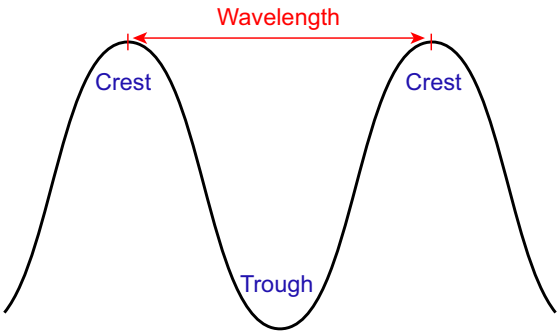


FIGURE 7.1
Wavelength and amplitude.

Most have heard the phrase "the speed of light." Sometimes this is explained with a reference to lightning. Because the speed of light (generally considered roughly 300,000,000 meters per second or 186,000 miles per second) is much faster than the speed of sound (generally considered 1120 feet per second or 761 miles per hour), you will see a lightning flash first; and then, depending on the distance of the lightning, the sound of the lightning can arrive several seconds later. Because the speed of light is so fast, and the distances you can see on earth relatively short, the "seeing" of light coming from any object on the earth appears "instantaneous."

When you look toward the heavens, things begin to differ. Because the moon is approximately 239,000 miles from the earth, it takes light approximately 1.28 s to travel from the moon to the earth. Because the sun is approximately 93,000,000 miles from the earth, it takes light approximately 8 min and 19 s to travel from the sun to the earth. This means that if the sun were immediately snuffed out and ceased to exist, apart from other terrible physical effects, you would still see the light of the sun for another 8 min and 19 s because you would still be seeing the light that is traveling between the sun and the earth until it all reaches the earth.

Why mention these interesting facts about the speed of light? It is to get you used to thinking in terms of seeing things some "time" after light left the source of the light. A time and a distance exist between a person's seeing something and the cause of those light waves. When an author is writing about light, some foundation is almost always warranted.

Fig. 7.2 is a representation of the entire EMS. On it, you can see the small area designated for **visible light** (see Fig. 7.3).

Visible light is generally regarded to be the range on the EMS between 400 and 700 nm. Immediately below the 400 nm range is the region of **UV light**, which is 100–400 nm.

Immediately above the 700 nm range is the region of **IR light**, with the region of IR applicable to photography being approximately 700–1100 nm.

Light Energy and Different Surfaces

Light, as a region of waves on the EMS, reacts in different ways when it strikes different surfaces. As manipulators of light, photographers should understand these interactions. Sometimes, you just need to be aware of these processes. Sometimes, you must control or manipulate the photographic variables to achieve different effects. The main reactions of light with the different substrates it strikes are (1) reflection, (2) absorption, (3) transmission, and (4) the conversion of light from one state to another, usually regarded as **Fluorescence**.

White light is the combination of various colors. Most are aware of the ability of a prism to "split" white light up into its component colors, which make up the rainbow as shown in Fig. 7.4.

When white light strikes some surfaces, there can be a total reflection of all the light. When all the light is being reflected, the result is an impression that the surface itself is white. Actually, the interpretation of paper being lit by white light as being white paper really means your eyes are being stimulated by all the reflected light coming off the paper. The eyes sense all the wavelengths of all the colors in the reflected light, and the brain interprets this combination of stimuli as a surface that is itself white. Technically speaking, the paper itself is not white; because it reflects all the light that strikes it, the brain "assigns" the color white to it.

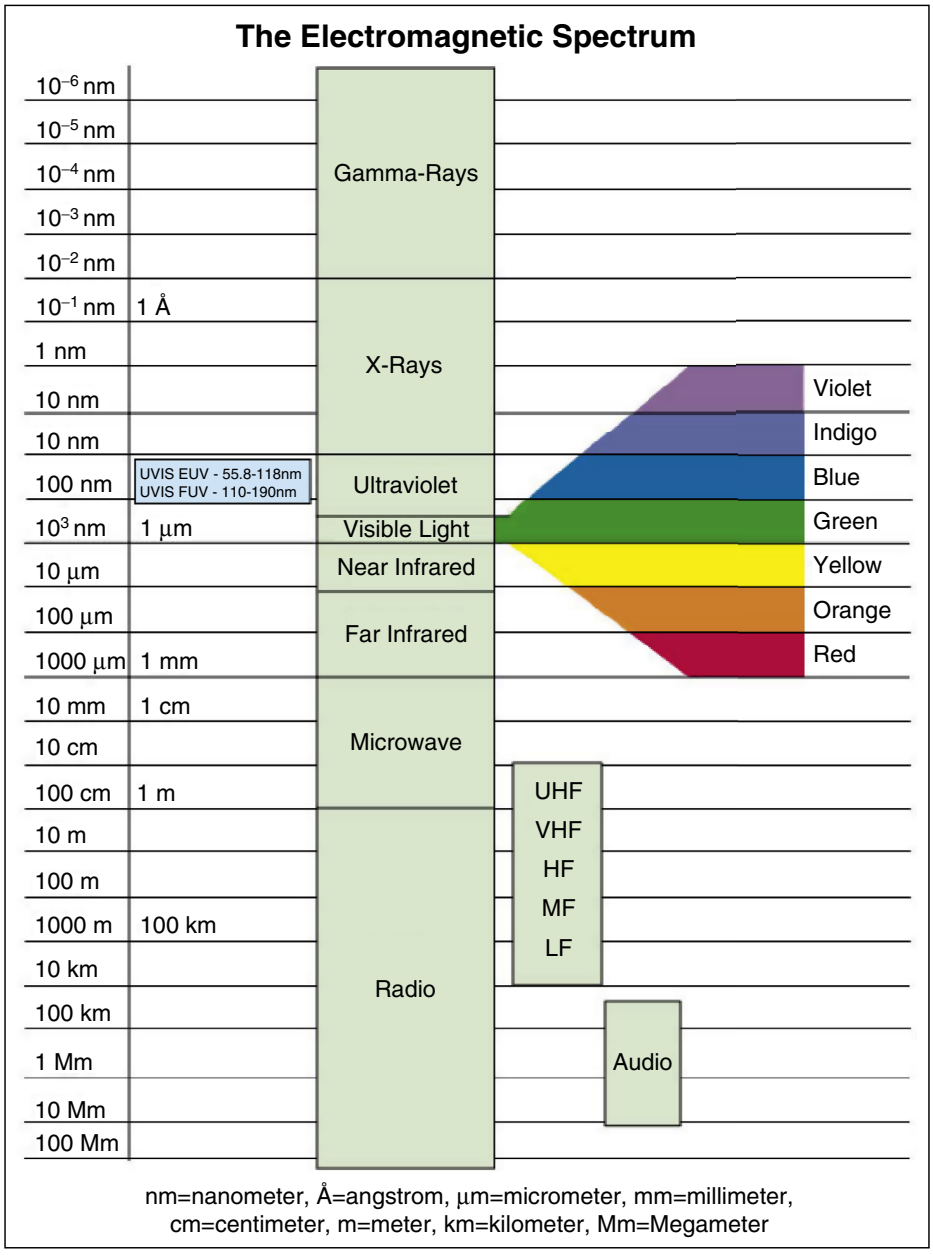


FIGURE 7.2
The **Electromagnetic Spectrum**.
http://lasp.colorado.edu/cassini/education/Electromagnetic%20Spectrum.htm.

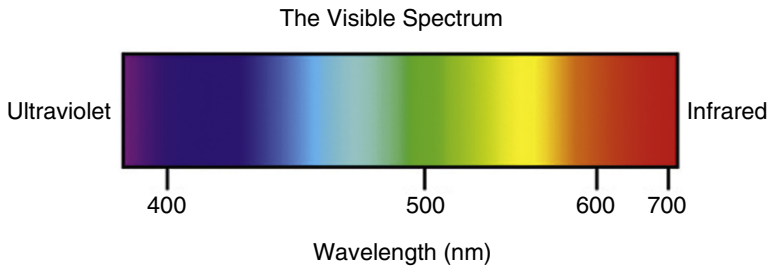


FIGURE 7.3
The visible light range.
Courtesy of Jeff Robinson, scamper.com.

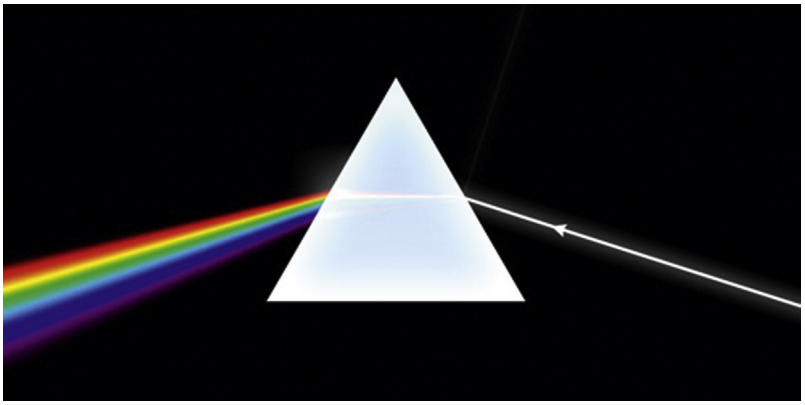


FIGURE 7.4
A prism splitting up white light.
Courtesy of Jeff Robinson, scamper.com.

When white light strikes some other surfaces, all the colors that make up white light can be absorbed by the surface. When no colors are reflected by a surface, the brain interprets this surface as being black. Technically speaking, this surface itself is not black; because it absorbs all the light that strikes it, the brain "assigns" the color black to it. Actually, black is the absence of color. It is really not a color at all.

Most surfaces partially absorb some parts of white light and partially reflect some parts of white light. The results are surfaces that appear to be colored or manifest varying shades of gray.

Why does someone say a shirt is red? It is "red" because when all the colors of the rainbow, white light, strike it, the material and dyes in the fabric absorb the violet, indigo, blue, green, yellow, and orange of the white light, and the shirt reflects only the red part of the white light. Why does someone say a dress is blue? It is "blue" because when all the colors of the rainbow, white light, strike it, the material and dyes in the fabric absorb the violet, indigo, green, yellow, orange, and red of the white light, and the dress reflects only the blue part of the white light. Why does someone say something is gray? An object is considered gray because only a portion of the white light striking it is being reflected, and some of the white light striking it is being absorbed. Being gray is a result of a surface partially reflecting white light and partially absorbing white light.

Besides being able to be reflected and absorbed by different surfaces, light can also be transmitted through some surfaces or materials. Obviously, you might think of glass and water right away. But, remember the result of putting one layer of handkerchief over an electronic flash head? The light still went through the handkerchief. It was just 1 stop dimmer because some of the light was absorbed by the cloth. Most of the light is transmitted through the cloth.

Some materials react to light quite differently. Some materials, certainly not all, will convert the light. First pointed out by Irish physicist George G. Stokes in 1852, some materials will absorb the light that strikes them and convert that light into a light of a longer wavelength and lower intensity, which is normally understood as **fluorescence**.

A stimulating light, usually from a laser or alternate light source (ALS), which emits a light of a known wavelength and frequency, can be directed onto a surface. That surface may sometimes totally absorb the stimulating light. Unlike what happens when no light is reflected from the surface, and the result is a perception of a black surface, molecules in the surface will become excited, and some of their electrons will rise to a higher electronic state. When they eventually return to their previous state, energy is emitted. Because a loss of energy occurs during this process (actually, the conservation of energy principle excludes the possibility of energy being destroyed or lost; in reality, some of the light energy is converted into heat energy that is dissipated into the material, which does reduce the net light energy remaining), the light subsequently emitted has a longer wavelength and lower intensity than the original stimulating light. Light of a longer wavelength and lower intensity also has a different color.

A classic example of the conversion of one light into fluorescent light is the use of an argon ion laser emitting what is perceived to be a blue light. Fig. 7.5 shows the laser emitting its typical blue light.

White fabric stained with semen is lit with room lighting and shown in Fig. 7.6A. Fig. 7.6B is the same semen stain lit with a blue light and photographed with an orange filter over the camera lens. Why use of an orange filter? As stated previously, the fluorescence stimulated by the laser is weaker in intensity than the original laser light. The stronger



FIGURE 7.5
The argon ion laser.

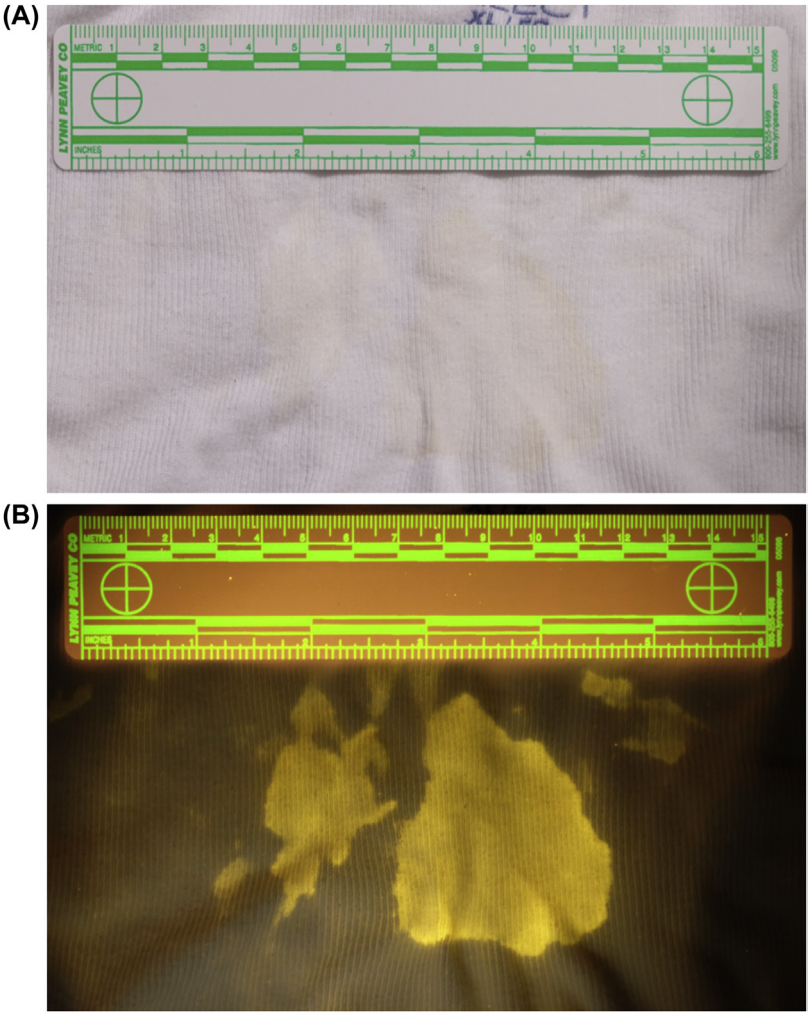


FIGURE 7.6
(A) Semen stain normal photograph. (B) Semen stain 455 nm blue light with orange excitation filter.
Courtesy of King C. Brown & M. Dawn Watkins.

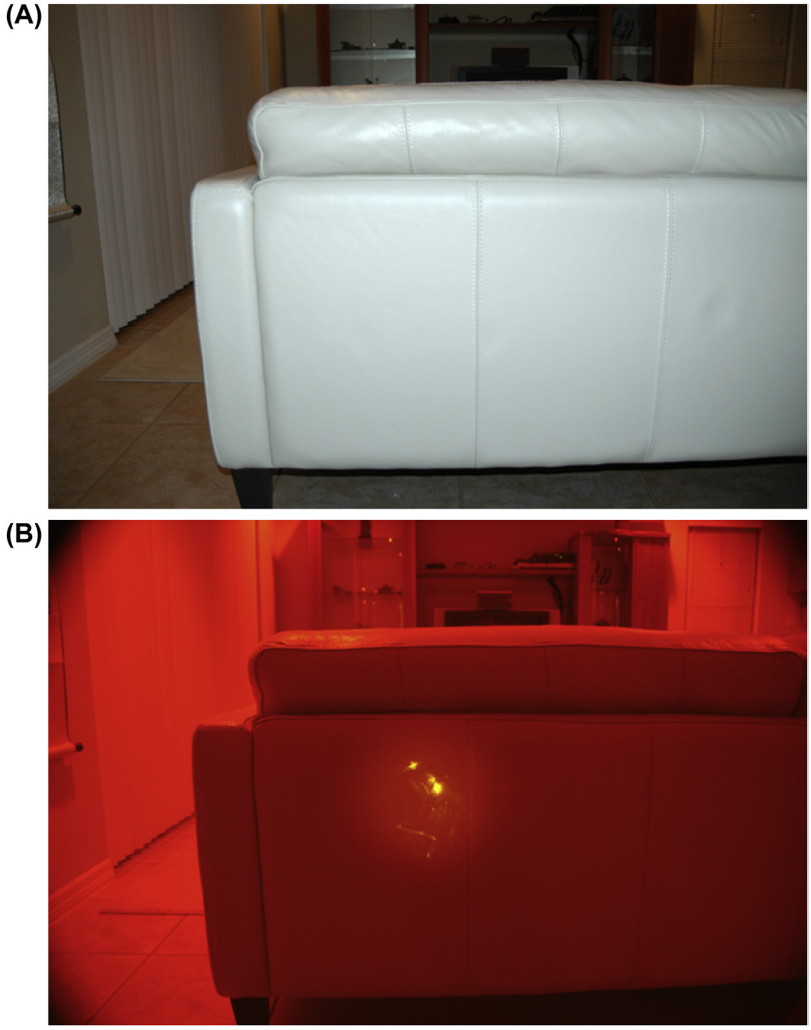


FIGURE 7.7
(A) Couch normally exposed. (B) The same couch lit with a 532 nm Coherent TracER Laser and an orange filter.
Courtesy of King C. Brown & M. Dawn Watkins.

light of the laser overwhelms the fluorescence it creates. To see and photograph the fluorescent semen stains, you need to eliminate the laser light without turning it off, and eliminating the original stimulating light is done with a filter. It is known that the fluorescence created by an argon ion laser usually occurs in the orange range of the visible light spectrum. An orange filter appears to be orange to human eyes because it absorbs all the other colors of the visible light range and reflects and transmits orange. By viewing the semen stain wearing orange goggles, you can see the fluorescence created by the laser without turning it off. The orange filter will absorb the blue light of the laser, while allowing the orange fluorescence caused by the laser to be seen. Put an orange filter on the camera lens, and the same view can be photographed.

Fig. 7.7A is a normal photograph of a couch cleaned up after a crime. Fig. 7.7B is the same couch lit with a 532 nm Coherent TracER Laser and an orange filter, Fig. 7.8 is a close-up of the reaction from the laser.

Fig. 7.9 displays a wall cleaned up before being lit with the 532 nm Coherent TracER Laser; Fig. 7.10 displays the cleanup fluorescing.

To photograph this fluorescence, you can use aperture priority exposure mode with an f/11 with the digital camera set to 400 ISO. Because the camera meter is designed to provide proper exposures for objects lit with visible light, it makes sense that the camera light meter may not be as successful with fluorescent objects. In fact, the result is usually a bit overexposured. When you are using the aperture priority exposure mode and photographing fluorescent surfaces, it is suggested you begin with an exposure compensation set to −2. You may bracket around that.

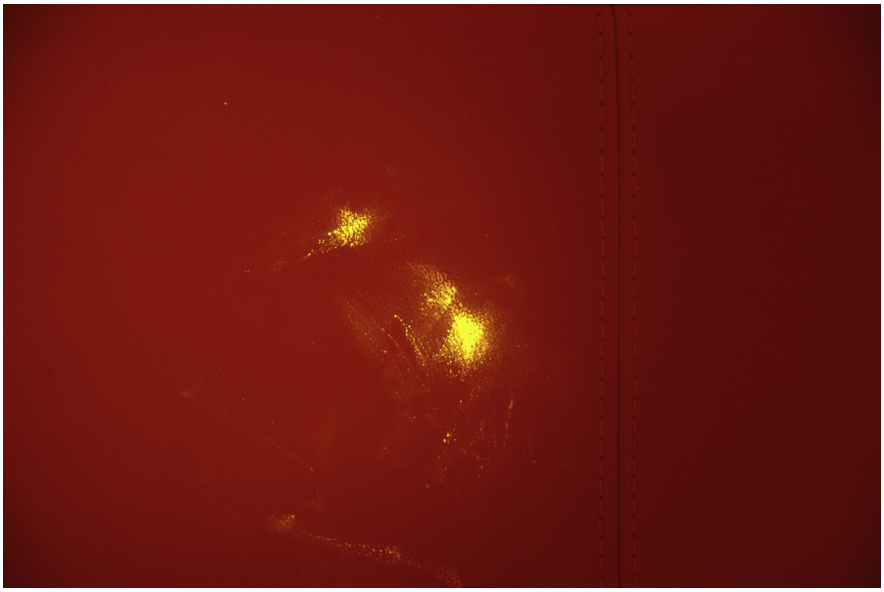


FIGURE 7.8
Close-up of the sofa stimulated with a Coherent TracER Laser, emitting 532 nm light used with an orange filter.
Courtesy of King C. Brown & M. Dawn Watkins.



FIGURE 7.9
A wall with a normal exposure.
Courtesy of King C. Brown & M. Dawn Watkins.

This exposure recommendation is made because the fluorescent subject is usually not filling the frame. It may be a few fluorescent fibers, a fingerprint or two, or a fluorescent body fluid stain. The meter, on the other hand, is trying to provide a proper exposure for the entire scene, most of which is not fluorescing. To bring the entire area up to an 18% exposure, you need to get more light to the area which is not fluorescing. The camera's meter will recommend an exposure to do this, which, unfortunately, overexposes the fluorescent subject matter. Knowing this is the tendency of the camera's light meter, adjust with a –1 or –2 exposure compensation and the background will become dimmer, allowing the brighter fluorescence to stand out better.

Because the term "fluorescence" has been used a few times, it is necessary to clear up the confusion that frequently is associated with three terms: **Luminescence**, fluorescence, and **Phosphorescence**. **Luminescence** is the general term that includes both fluorescence and phosphorescence. Luminescence means a molecule's ability to emit light from causes other than heat. These causes can include a stimulation by a beam of photons (light), an excitation by chemical or biochemical means, and others.

Incandescence is an example of fluorescence caused by heat. Fluorescence and phosphorescence are both types of luminescence. What differentiates them? Fluorescent materials emit a "glowing" light only while they are currently being stimulated by a stronger, higher-intensity light. Turn off the stimulating light, and the fluorescence also immediately ends. **Phosphorescence** describes the ability of some materials to retain some of the radiation they have absorbed from a stimulating light and then continue "glowing" after the stimulation has ceased.

This energy can then be released over long durations. Some children's toys designated as "glow in the dark" toys are phosphorescent. Expose them to light once, and they can continue to glow long after the lights have been turned off.

When a crime scene is searched for evidence that is currently not visible with the normal room lights on, UV lights, forensic light sources (usually understood as nonlaser light sources emitting only one color of light), lasers, and ALSs (usually understood as nonlaser light sources capable of emitting a variety of different lights) are used to stimulate potential evidence so it will fluoresce and become visible.

Some standard combinations of lights and filters are well known:

- If a UV light is being used to stimulate fluorescence, the stronger UV light can be absorbed by either a UV filter or a yellow filter. Doing so allows the weaker fluorescence to be seen.



FIGURE 7.10
The wall stimulated by a Coherent TracER Laser viewed through an orange filter.
Courtesy of King C. Brown & M. Dawn Watkins.

RULE OF THUMB 7.01

When searching a crime scene with a forensic light source, or an alternate light source emitting a UV light, use a UV filter or a yellow filter to see and photograph the fluorescence generated.

- If a blue light (which can be emitted by a laser, forensic light source, or an ALS) is used to stimulate fluorescence, the stronger blue light can be absorbed by using an orange filter. Doing so allows the weaker fluorescence to be seen. Fig. 7.11 shows a semen stain fluoresced with a UV light (A) and with a 455 nm blue light with an orange filter (B).

RULE OF THUMB 7.02

When searching a crime scene with a forensic light source, laser, or an alternate light source emitting a blue light, use an orange filter to see and photograph the fluorescence generated.

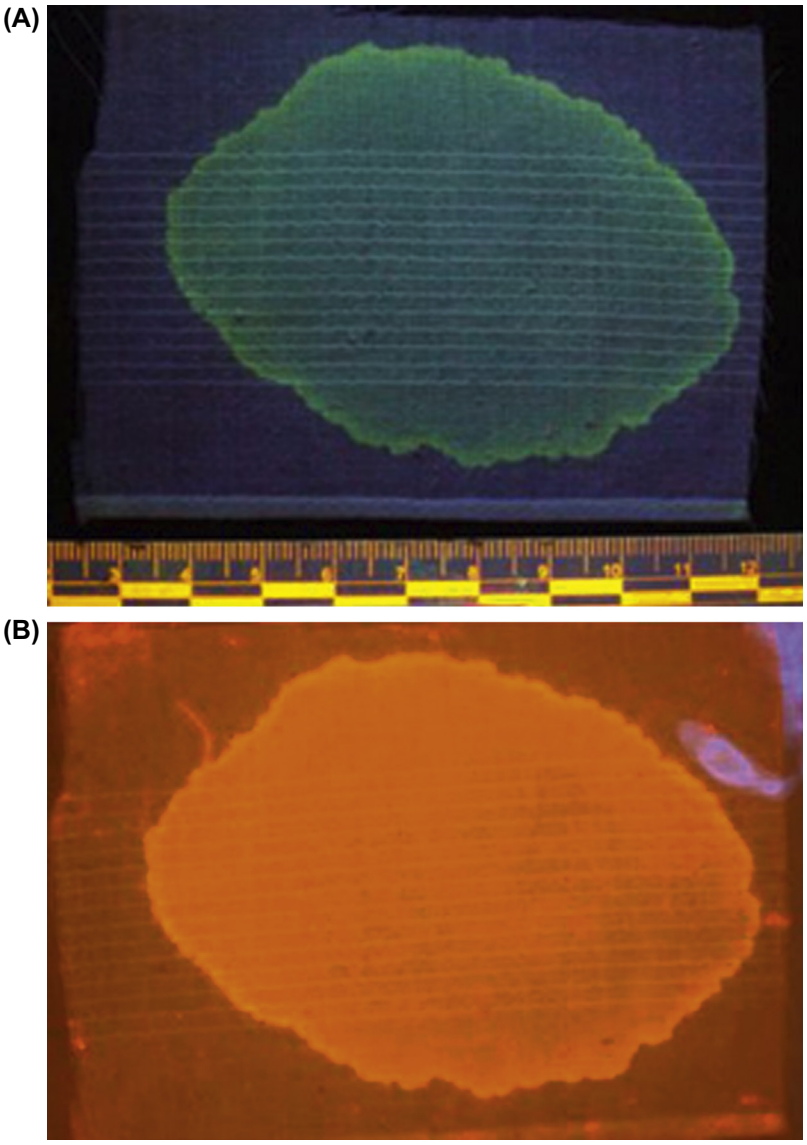


FIGURE 7.11
Seminal stain lit by ultraviolet (A) and an alternate light source emitting blue light filtered with an orange filter (B).

- If a green light is used to stimulate fluorescence, the stronger green light can be absorbed by use of a red filter. Doing so allows the weaker fluorescence to be seen.

RULE OF THUMB 7.03

When searching a crime scene with a forensic light source, laser, or an alternate light source emitting a green light, use a red filter to see and photograph the fluorescence generated.

Because some materials fluoresce only when stimulated by one particular light, having the ability to search a crime scene with a variety of different lights will typically yield the recovery of more evidence. Not all evidence will fluoresce when just stimulated with a blue light. However, should you work with an agency with a restricted budget, if you were able to purchase only one kind of fluorescent light, the blue light fluoresces most of the types of evidence crime scene photographers search for and photograph.

ULTRAVIOLET LIGHT

As mentioned previously, UV light is located on the EMS between 100 and 400 nm. UV light can be characterized as being long-wave UV (315–400 nm), medium-wave UV (280–315 nm), or short-wave UV (200–280 nm). Long-wave UV is the region sometimes described as being "black light" UV, or sometimes it is called the "disco light" range. In this range, clothing sometimes appears to glow brightly. This would suggest long-wave UV light might be useful in locating difficult-to-find trace fibers. Long-wave UV light was the first crime scene light used to search for blood, non-blood body fluids like semen at rape scenes, and fluorescent fibers. Before lasers and ALSs became the most frequently used light sources at crimes scenes, long-wave UV light was the only light able to visualize many types of "invisible" evidence. It still does these jobs well, and many agencies with limited budgets can still locate and collect many kinds of evidence with just a long-wave UV light. A long-wave UV light is normally a light emitting approximately 365 nm.

Short-wave UV light did not have a use at crime scenes until the advent of the **Reflected Ultraviolet Imaging System (RUVIS)**. This equipment uses high-intensity short-wave UV light to visualize *untreated* latent fingerprints. It does this job extremely well. Krimesite Imagers are one brand name of RUVIS systems and revealed an untreated latent fingerprint on the side of a cabinet where no prints could be seen otherwise. Fig. 7.12 shows the view of the latent under short-wave UV lighting, and the subsequent powder-processed print.

Subsequent use in the field and research indicates that RUVIS systems should not be used at a crime scene until all samples of blood and body fluids have first been collected. Short exposures of DNA evidence to short-wave UV light can preclude the eventual successful typing of DNA. The tool is still very useful. It must be used judiciously, however, and not until all DNA samples have been collected and removed from the crime scene.

UV light is also sometimes divided into UVA (315–400 nm), UVB (280–315 nm), and UVC (<280 nm). UVA is considered the "tanning" region of UV light. UVB is considered the region of UV light that is responsible for sunburn and sun damage to skin. UVC is considered "germicidal." UVC is sometimes used as a nonchemical disinfectant because it can kill germs effectively, which is also the reason that UVC, or short-wave UV light, should not be used around DNA samples. It can also prevent the typing of DNA samples.

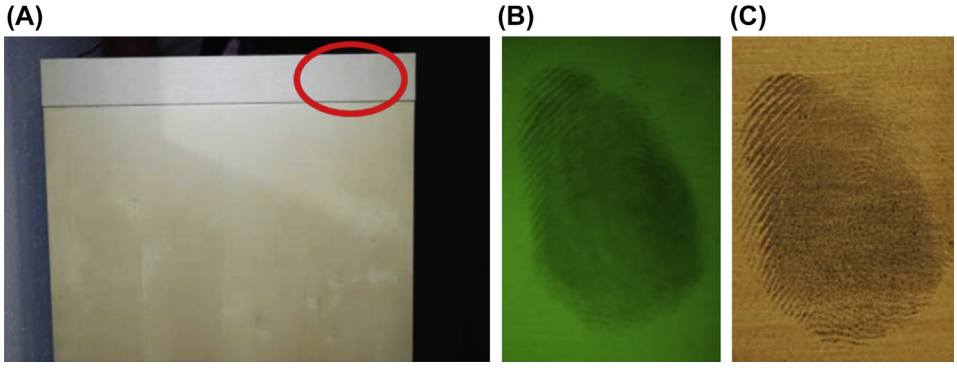


FIGURE 7.12
A cabinet viewed with room lights (A), with reflected ultraviolet imaging system (B), and the print processed with powder (C).
Courtesy of M. Geniuk, GWU MFS student.

One other general comment should be made about UV photography before specific examples of its application are addressed. It was previously discussed in chapter "Basic Exposure (Non-Flash) Concepts" that attempting to capture images in the IR region sometimes required a focus adjustment. Most cameras' focusing systems are designed for visible light, not IR light. Attempting to capture detail in the UV will also sometimes require a focus adjustment. The focusing adjustment for UV photography, however, is not clear with just a cursory reading of the literature. Much of this literature was written before digital cameras became the primary cameras used at crime scenes. However, now that there are digital cameras specifically designed to capture UV and IR images, the need for the focusing adjustments which film required are no longer a concern.

There are several variables that relate to UV photography. First and foremost is the need for a camera that is UV sensitive. Many black-and-white films were sensitive to UV light, particularly T-MAX 400. However, most digital cameras are currently designed to be sensitive only to the visible light range. To do digital UV photography, you must seek out specialized digital cameras that have sensors which are sensitive to UV light. In 2007, the Fujifilm IS Pro was launched, boasting UV-VIS-IR sensitivities. It seemed like it might corner this market. However, at this time, the production of this camera has been discontinued.

Another necessity is to have a lens that transmits UV light. Not as easy as it might sound! Most camera lenses have multicoatings added to the exterior element of the lens, which among other things block UV light. For most traditional photography, UV light is not needed, and lens manufacturers designed lenses to prevent UV light from transmitting through the lens to alter visible light exposures. The glass elements themselves also blocked a majority of the UV light that might be present, one source indicating that traditional lens glass elements block UV below 350 nm. The lens shown in Fig. 7.13 is the excellent 60 mm 1:4 UV-VIS-IR Apo Macro lens from Coastal Optical. This is a specialty lens designed for use when shooting in the UV and IR ranges.

It is known that quartz lenses are better at transmitting UV light. A step up is a combination quartz/fluoride lens, which transmits UV light. In 1984, however, a specialty lens from Nikon was designed: the Nikon UV-Nikkor 105 mm f/4.5s. With its phosphate lens elements, it would transmit UV between 220 nm and visible light. These lenses, however, are rare and quite expensive. This makes photography, requiring UV light, difficult to do.

Reflected Ultraviolet Photography

Reflected UV photography involves capturing images with only long-wave UV light being allowed to strike the film or digital sensor, as mentioned previously.



FIGURE 7.13
The Fujifilm IS Pro UV/IR digital camera, with the Coastal Optical 60 mm 1:4 UV-VIS-IR Apo Macro lens.
Courtesy of Fujifilm USA and Coastal Optical Systems, Jupiter, FL.

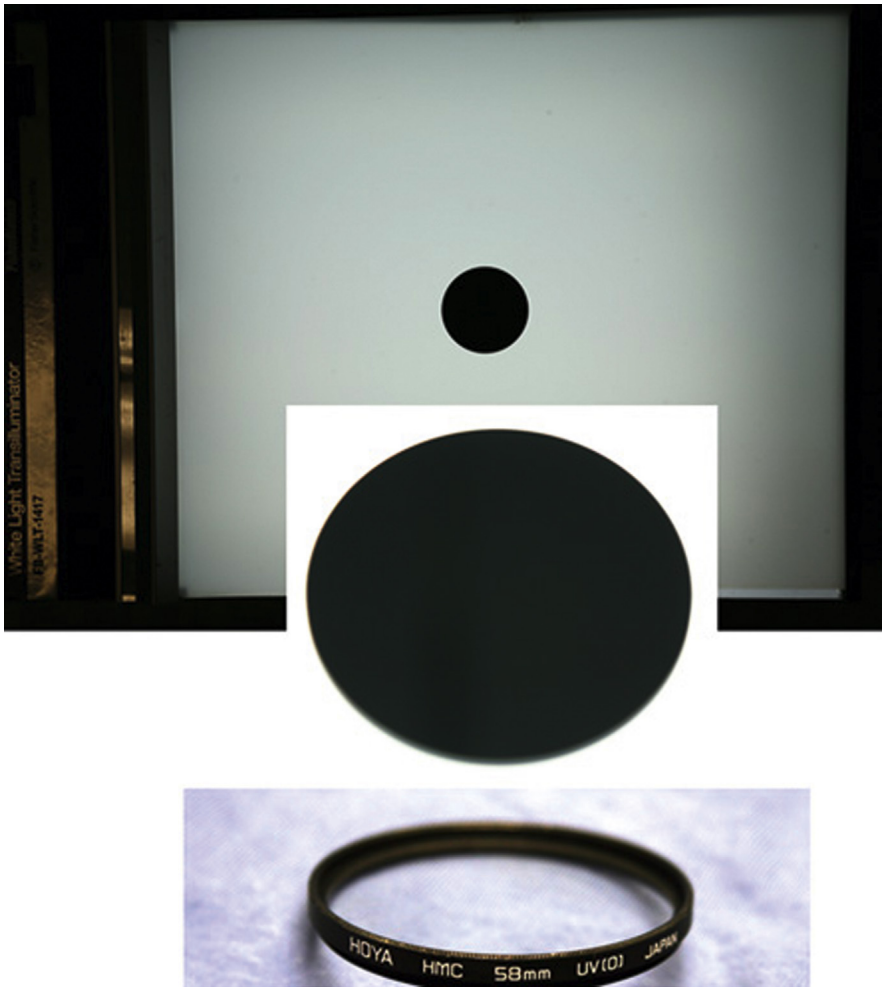


FIGURE 7.14
Ultraviolet (UV)-blocking and UV-transmitting filters.

As such, reflected UV is perhaps one of the most difficult types of photography. In addition to what has already been discussed, if the image will be made with nothing but UV light, it will be necessary to block all visible light from entering the lens. One way to accomplish this is to simply turn off the lights and make sure no stray visible light is entering the room through door cracks or window edges. Working in the dark is very troubling for most people, with the need to turn the lights off and on many times required. Perhaps the best way to eliminate visible light is to use a filter that blocks all visible light while allowing UV light to be transmitted through it. An 18A filter does just this. This filter is not to be confused with the UV filter or 1A filters previously mentioned as lens protection. Both of these filters block UV light while transmitting visible light. Fig. 7.14 shows both a UV filter, which blocks UV light while transmitting visible light, and an 18A filter, which blocks visible light while permitting the transmission of UV light through it. Notice that the 18A filter appears opaque because it blocks all visible light.

Although the 18A filter is advertised as the filter of choice for reflective UV photography, a close reading of its specifications reveals that besides transmitting UV light and blocking visible light, as advertised, it also transmits some IR light. This becomes particularly problematic if using this filter on a lens that is also advertised as a UV/IR-capable lens. If this filter and lens combination is then used with a digital camera that claims to be UV and IR sensitive, unexpected results might be noticed. If the digital camera is more sensitive to IR than to UV, the images captured while doing UV reflective photography may look suspiciously like other IR images you have taken. These results are what this author has experienced, along with many others. What is to be done? It would be nice if reflective UV photography could be simplified. Newly available UV/IR cameras will be mentioned later in this chapter.

What are the applications best suited for reflective UV photography? Predominantly, this type of photography has two main uses: questioned document examiners will use this type of imaging to help them differentiate between inks that may look similar when viewed in visible light. A document may have been altered with a different pen than the one that wrote the original words. Words, letters, or numbers may have been added to the original writing to change the meaning of the words or to change the value of checks or other monetary instruments. Even though many pens have similar black inks when viewed with visible light, sometimes these inks can be distinguished when viewed under different light sources. The different inks may show a varying tendency to absorb, reflect, transmit, or fluoresce when viewed under different lights.

Reflective UV light can also sometimes visualize deep muscle bruising that has healed and is no longer visible with normal lighting. Every text dealing with forensic photography sooner or later refers to the article in the November 1994 issue of the *Journal of Forensic Science*, in which T.J. David and M.N. Sobel reported a case study in which they were able to photograph 5-month-old bite marks on the shoulder of a rape victim with reflective UV photography. They compared the photographed bite mark to the known dentition of a suspect, and their identification of the two was responsible for the conviction of the suspect. The photographs published in the case study should make everyone grateful for the experienced eyes of experts because those photos did not reach out and shake this author with their obvious similarities.

The foundation for the use of reflective UV photography in circumstances of deep muscle bruising is based on the migration of melanin to the wound's perimeters beneath the skin during the healing process. Melanin absorbs UV light, and even if the wound can no longer be seen in normal lighting, patterned wounds or injuries can sometimes be detected with reflective UV light long after the initial injury. Another article published by the same authors relates to the observation of subcutaneous wound patterns 7 months after the original incident. Apparently, the optimal time period for the visualization of deep muscle bruising with reflective UV photography is between 3 weeks and 5 months. Before that, visible light photography and IR photography should be attempted.

What camera settings are required for reflective UV photography? The biggest problem is that camera meters are not designed to provide proper exposures for UV lighting. Because different subject matter may react differently to UV light, no standard exposure combination can be recommended. Each time reflective UV photography is to be done, it is wisest to conduct a series of tests on the subject matter of interest. The most common situation is provided:

Reflective UV photography using an electronic flash as the light source:

- Use an 18A filter over the lens.
- Use T-Max ISO 400 film.
- Use the sync shutter speed.
- The exposure tests are done by varying the f/stops through the full range of f/stops offered by the lens.

Absorbed Ultraviolet Light in the Visible Light Range

As mentioned previously, UV light was one of the first search lights for nonblood body fluids, particularly semen at rape scenes. It is still an excellent choice for this task. But, it is also an ideal light to search for faint bloodstains. Blood on many surfaces will be easy to see. Blood on substrates that are similar in color to blood can be very difficult to see. That is good for crime scene photographers. If the suspect does not see it, he may not try to wipe it away or wash it from the surface. Blood on multicolored substrates can also be hidden. In these cases, the use of a long-wave UV to search for and find "invisible" bloody residues can have remarkable effects. Even though UV light is being used, the result can be seen in the visible light range.

Fig. 7.15 shows a blouse of multicolored cloth as seen in visible light, which does not show any bloodstain pattern, except for a few stains at the back of the right sleeve. Light the same cloth with UV light, and the blood absorbs the UV light and appears to get darker, while the UV light makes the dark fabric appear lighter, so it can easily be seen. See Fig. 7.16.

Another example shows the effect of visualizing faint bloodstains with UV lighting. Fig. 7.17 shows the same piece of fabric that was prepared with a very a dilute blood/water mixture. The dilution was increased and increased until any staining with the fluid left no obvious bloodstain. After the fabric was dry, it was lit with six types of lighting. Top left to right: fluorescent room lighting, then with an oblique flashlight, and then long-wave UV light. Bottom left to right: blue light with an orange filter, green light with a red filter, and IR light. As you can see, if you were searching a crime scene trying to detect an attempt to clean up a bloody event, using the long-wave UV light would provide the best chance of a success.



FIGURE 7.15
Normal photograph of shirt with bloodstains.
Courtesy of King C. Brown & M. Dawn Watkins.

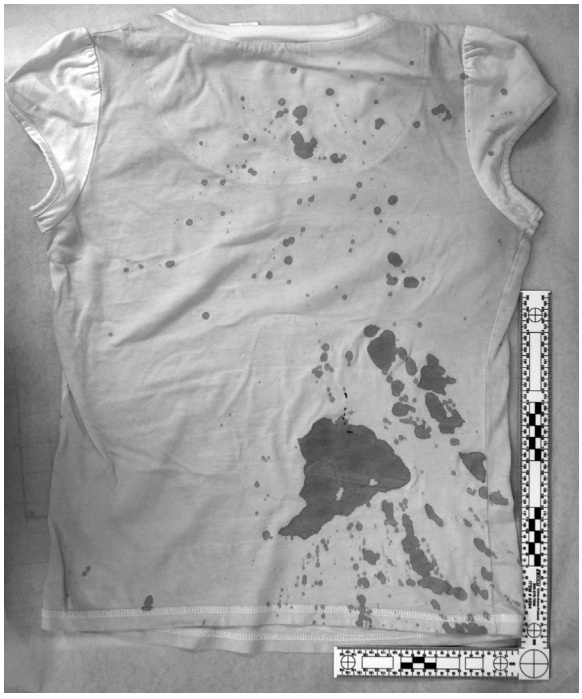


FIGURE 7.16
Ultraviolet absorbed by blood.
Courtesy of King C. Brown & M. Dawn Watkins.



FIGURE 7.17
Bloodstained shirt lit by different lights.

The literature indicates that an ALS emitting a blue light will also act much the same way. This author's experience is that UV light does a superior job in visualizing faint bloodstains.

Because this is visible light photography, normal exposures can be used: ISO 100 film, f/11, place the camera on a tripod and use aperture priority exposure mode. This will determine the shutter speed.

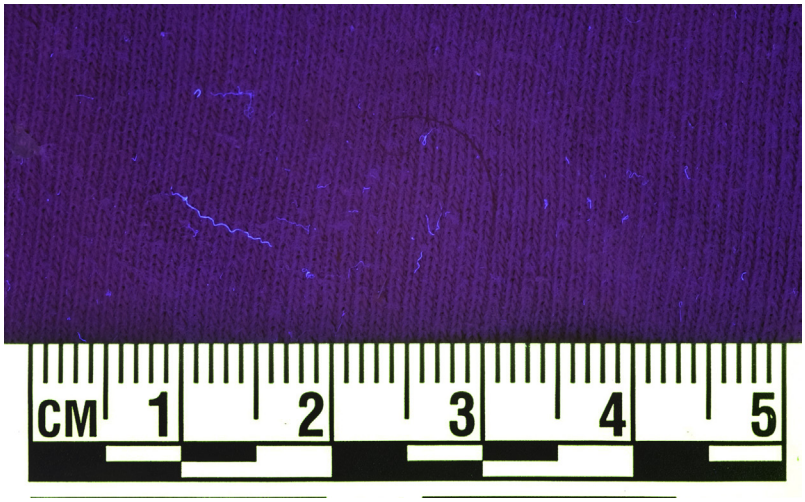


FIGURE 7.18
Ultraviolet fluorescence of fibers.
Courtesy of King C. Brown & M. Dawn Watkins.



FIGURE 7.19
Ultraviolet fluorescence of fingerprints.
Courtesy of King C. Brown & M. Dawn Watkins.

Ultraviolet Fluorescence Photography

UV light can also stimulate fluorescence in the visible light range, which is one example of the Stokes shift. The UV light is absorbed by various substrates and is changed. Some of the light energy is absorbed by the substrate as heat energy. What is left is emitted as a longer wavelength of light that is also less intense. To view and photograph the fluorescence caused by the UV light, you can use a UV-absorbing filter (camera filters called UV, 1A, 2A, or 2B). It would also be possible to see and photograph the fluorescence through a yellow filter.

Fig. 7.18 shows UV light creating fluorescence when certain fibers are stimulated by UV light. The nonsweater fibers were not visible until lit with the UV light. The fingerprints in Fig. 7.19 were processed with a fluorescent powder and lit by UV light. Because this is visible light photography, one might expect that normal exposures can be used. However, camera exposure meters are designed to provide proper exposures for normally lit subject matter. Fluorescence is definitely not a normal situation. Experience has shown that better exposures are often obtained with exposure settings dimmer than the meter may indicate. When in doubt, bracket.

It must be mentioned that any time you are using UV light, you should also be wearing protective goggles. The protective goggles can be UV goggles, which appear clear, or yellow goggles. Sunglasses not only eliminate the glare from the bright sun but also frequently block the UV light coming from the sun. Too much UV light can not only cause sunburn to the skin but also damage your eyes.

Fluorescence in the visible light range can be photographed with 100 ISO film, f/11, aperture priority exposure mode with an exposure compensation set to −2. When doing examination quality photographs, it is best to bracket just to provide the latent print examiner other exposures to evaluate. Then the image is a result of fluorescence, it would be a good practice to also consider a −2 exposure also. Of course, seeing the instant results with our digital cameras will confirm which bracketing might be most helpful.

INFRARED LIGHT ON THE ELECTROMAGNETIC SPECTRUM

The **Photographic IR Range** is in the near-IR part of the EMS, 700–1100 nm.

The human eye and normal digital sensors cannot sense IR light, so it will be necessary to have a camera sensor that is sensitive to IR light. Digital cameras, which are sensitive to IR light, have quickly eliminated the need to use IR film. Not all digital cameras are sensitive to IR light. Most digital cameras have filters over the digital sensor that filter out IR light. Digital cameras can have these filters removed by professionals to make the camera sensitive to IR light. This usually means that these cameras cannot be used for normal daylight photography.

One important benefit of a digital camera sensitive to IR light is that, because the camera is sensitive to IR light, the camera can also focus on IR light, and the previously required IR focus adjustment is no longer necessary. Digital cameras can also properly expose for IR light, eliminating much of the guesswork related to IR exposures when film was used.

Obtaining a digital camera sensitive to the IR range of the EMS is much easier than you might think. Of course, some digital camera manufacturers will modify one of their current single lens reflex (SLR) cameras so they can be used for IR imaging. This will provide the highest resolution of digital image but it can be costly. Another point of view is to use a digital camera with IR capability as a crime scene search tool. In this situation, it is just necessary to be able to visualize the currently "invisible" evidence. One camera manufacturer makes camcorders and point-and-shoot digital cameras with IR capability. Sony used to make cameras with "night shot" capability, which has a near-IR capability. All that would be necessary to convert any of these "night shot" capable cameras to full IR capability is to obtain the normal IR filter, which is a Wrattan #87 filter. This filter blocks all visible light while transmitting IR light through it. Therefore, to the eye, it appears opaque.

Fig. 7.20 shows an old Sony 717, 5 megapixel, digital camera. It is also shown with a #87 filter over the lens. The key is to use any of the Sony cameras that have "night shot" capability, also shown in Fig. 7.20. This camera has taken many of the images that follow. Used Sony 717/828s are also frequently available on eBay and Amazon.com at very reasonable prices.

Sony is not the only digital camera manufacturer making cameras with IR sensitivity. Canon also has made a digital SLR modified for IR work. See Fig. 7.21.

Due to the popularity of UV/IR photography there are several conversion companies, which will convert your digital camera by removing the cut filter and replacing it with clear glass. See Fig. 7.22.

Fuji also previously announced a digital SLR specifically modified to be used in the UV/IR ranges, the Fujifilm IS Pro. This camera became available in 2007 and is still an excellent camera for UV/IR images; however, it has been discontinued.

In August of 2015, FUJIFILM North America Corporation introduced the FUJIFILM X-T1 IR (Infrared), the first advanced IR X-Series mirrorless camera that delivers high performance in demanding fields for forensic experts. The FUJIFILM X-T1 IR adds advanced IR technology to see light from the UV, visible, and IR portions of the light spectrum (approximately 380–1,000 nm). The X-T1 IR is a premium mirrorless camera specifically designed for professionals and pairs seamlessly with each high-quality FUJINON XF lens for reliable and outstanding results. IR imaging is critically important in these fields because it allows users to see information that is not visible to the human eye. The exterior of the X-T1 IR is constructed of 100% magnesium alloy and is built to be weather resistant, perfect for use in hot or cold, wet or dusty, and other challenging weather conditions. The X-T1 IR has approximately 80 points of weather sealing for outdoor dependability and can withstand freeze temperatures down to 14°F (−10°C). This camera will prove to be an excellent camera system for the forensic investigators either in the lab or the field. See Fig. 7.23.



FIGURE 7.20
Sony 717 with night shot/infrared capability.



FIGURE 7.21
Canon digital camera modified for infrared (IR).
Courtesy of Tom Beecher, Photografix, Richmond, VA.



FIGURE 7.22
Camera conversion photo.
Courtesy of Owen McDonald, Mo Forensics LLC.





FIGURE 7.23
Fuji X-T1 IR camera introduced in 2015.
Courtesy of King C. Brown & M. Dawn Watkins.

Since UV/IR imaging is critical to forensic examinations, Arrowhead Scientific introduced a new 16 MP full spectrum imaging camera (FSIS). This is the most advanced electronic UV/IR camera in the world. The FSIS camera with sensitivity from UV, through the visible and into the near-IR spectrum makes capturing and viewing latent prints, gunshot residue (GSR), and bloodstain patterns easier and more efficient. With over 16 MP of resolution and sensitivity from 254 to 1100 nm, the 16 MP can easily capture a full handprint at 1000 PPI (pixels per inch) resolution. The FSIS will capture in high resolution and in real time. The FSIS is able to provide consistent sensitivity and sharpness in the UV, visible, and IR spectrums. The original image can be saved in both IMG format as well as TIFF. See Figs. 7.24 and 7.25.

Why is having the capability to immediately "see" and photograph a crime scene with IR light important? In the past, some agencies had the capability to capture IR images at crime scenes only with IR film. This meant that these images would have to be processed before they could be seen. Only then would the investigator have the information revealed by the IR images. These days, with an inexpensive digital point-and-shoot digital camera or an equally inexpensive digital camcorder, evidence not previously seen can be inspected and reviewed *at the crime scene* for information that can provide immediate investigative leads or information that can be used as probable cause in obtaining a search warrant or may even be probable cause in making an arrest. This point cannot be overemphasized.

What are the types of evidence IR can reveal at a crime scene? This evidence usually falls into four categories:

- Visualizing Ink differentiations (questions documents, tattoo alterations)
- Visualizing GSR
- Visualizing the writing on burned documents
- Visualizing blood stains

What are the effects of IR light on different substrates?

- The substance may absorb the IR light. If this occurs, the substance absorbing the IR light will remain dark, or if it currently is dark, it will appear to darken.
- The substance may reflect the IR light. If this occurs, the substance reflecting the IR light will appear to lighten in color or tone. If it currently is black, it will appear to turn a lighter shade of gray, or it may appear to turn white.
- The substance may transmit the IR light. If this occurs, the substance transmitting the IR light may appear to disappear, revealing whatever is beneath it.
- The substance may convert the IR light. If this occurs, the substance converting the IR light will convert some of the energy present in the IR light into heat. The weaker energy remaining will then be emitted by the substance as light of a longer wavelength, which is also of a weaker intensity. This light is fluorescent.

Regarding ink differentiations, the dyes and pigments in the ink will show these various effects, and even inks that appear a similar shade of black can show some very drastic changes.

Figs. 7.26 and 7.27 show all these effects. In the top left of Fig. 7.26, all four inks are being stimulated by visible light, and the result is being visualized in the visible light spectrum. All the inks appear to be dark. In the bottom left image, the top ink is now reflecting IR light and now looks like white ink. The third ink has become fluorescent in the IR range, and the fourth ink has gone transparent. In the bottom right, three of the same inks have reacted to the IR light by going fluorescent. In the top right image, just one ink is fluorescing. Here you can see just how valuable it would be to have various types of IR one can use on the evidence. The lower left image is capturing the image at the 735 nm (all the second figures in this four-some of images should have been "nm") range of IR and the lower right image is capturing the image at the 850 nm range of IR.

Fig. 7.27 shows that many inks become transparent when lit by IR light.

These effects become more interesting when they are associated with casework. Usually, it is just important to establish that some portion of a document was written at a different time with a different pen. If a letter, number, or word can be made to react to light differently, this has been established.



FIGURE 7.24
Full spectral imaging system.
Courtesy of Arrowhead Scientific.



FIGURE 7.25
Full spectral imaging system.
Courtesy of Arrowhead Scientific.

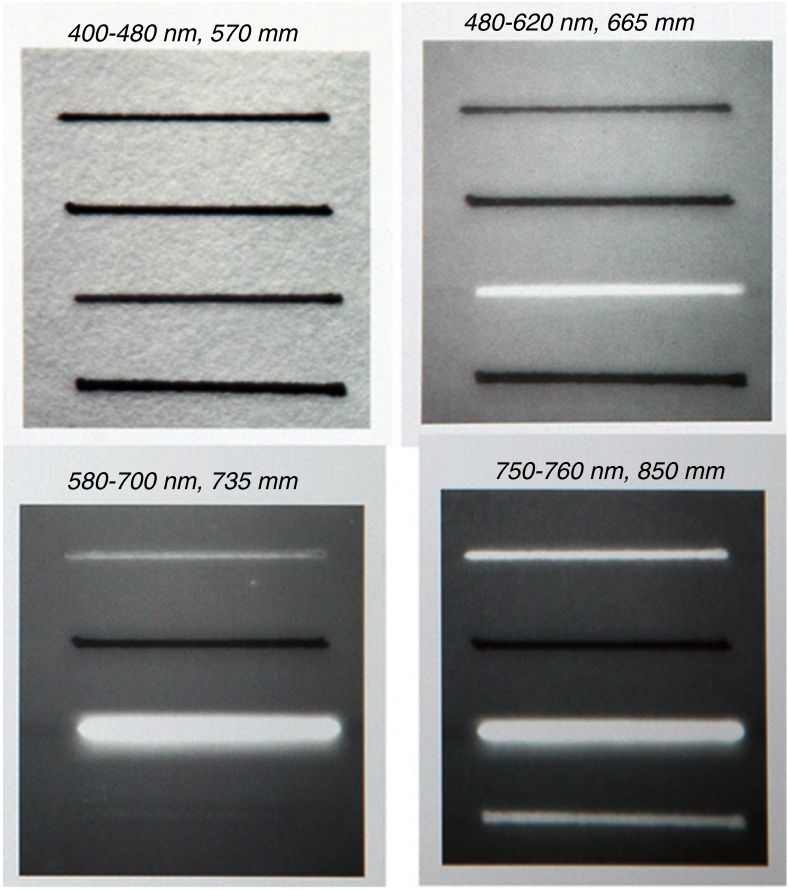


FIGURE 7.26
Inks reacting to various lights.
Courtesy of Jeff Wilson, GWU MFS student.

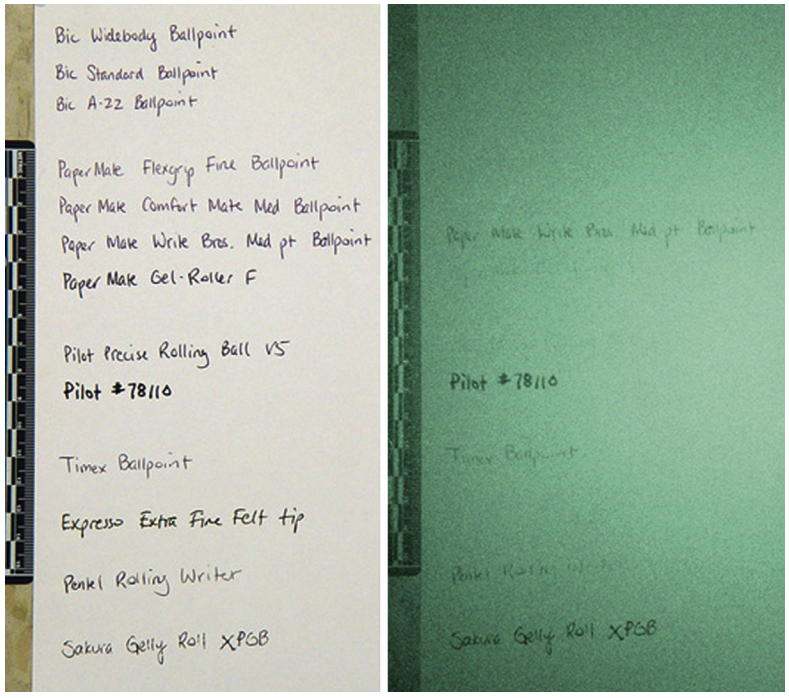


FIGURE 7.27
Inks becoming transparent in infrared.

Fig. 7.28 shows an example of an altered check, where the amount of $71.00 had been altered to read $171.00. If the inserted number "1" and the inserted word "one" can be shown to be different than the original ink, the effort will be successful. In the IR range, both the word "one" and the number "1" are semitransparent to IR light, and they become near invisible with an #87 IR filter. Had there been any allegation that the original document was written for $171.00, the below image would disprove any such claim.

Fig. 7.29 takes a similar case and adds a second level of proof. A check originally written for 100 dollars had been altered to read 5100 dollars. Under one view with IR light, the number "5" and the word "Fifty" go transparent (B).

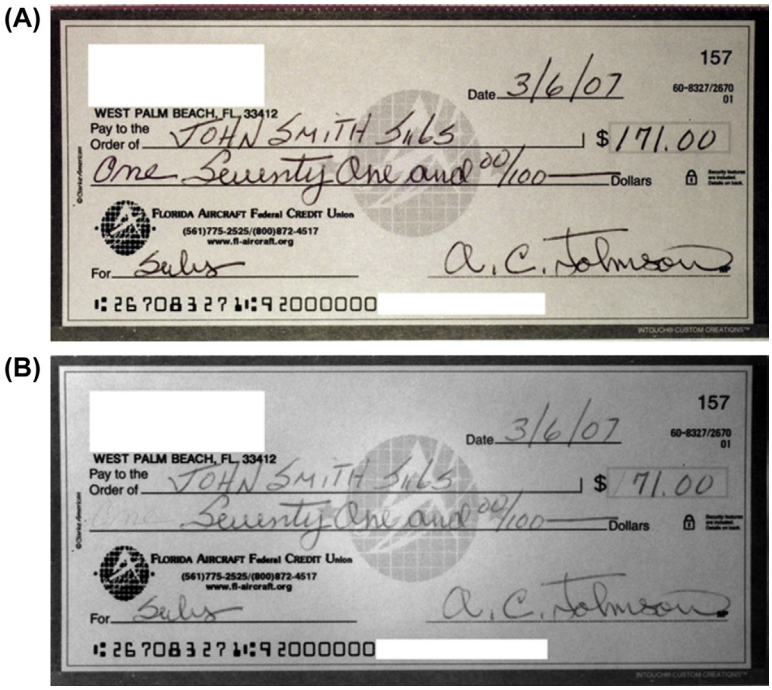


FIGURE 7.28
(A) Altered check normal photograph. (B) Visualized check using infrared and 87 IIR filter.
Courtesy of King C. Brown & M. Dawn Watkins.

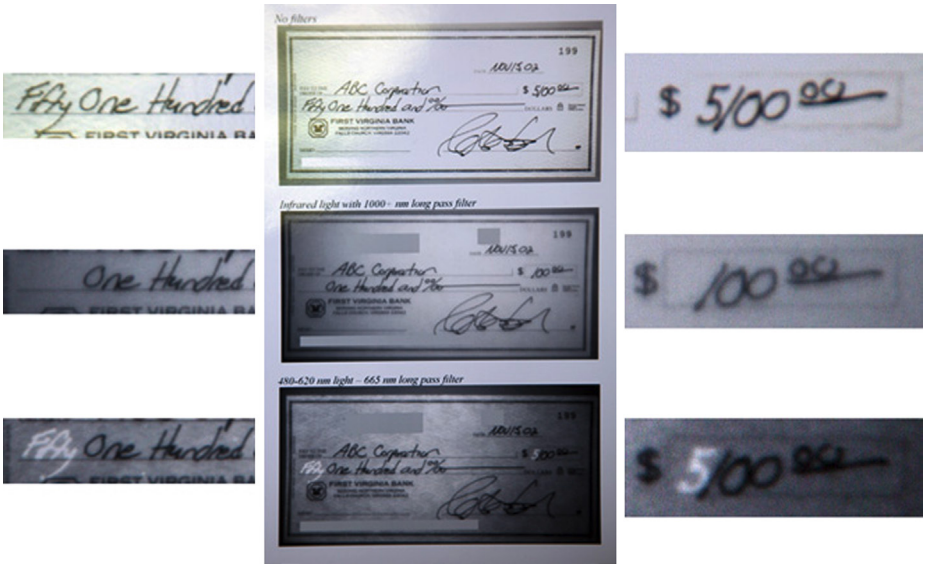


FIGURE 7.29
Infrared lighting both fluorescing and eliminating the alterations.

Under a different region of IR light, the number "5" and the word "Fifty" fluoresce (C). It would be very difficult convincing any jury the original check was anything other than 100 dollars.

Fig. 7.30 shows an obliteration of information of a subject who did not want falling into the hands of the law enforcement officials approaching with a search warrant. In this case, it was fortunate that the original note was written with

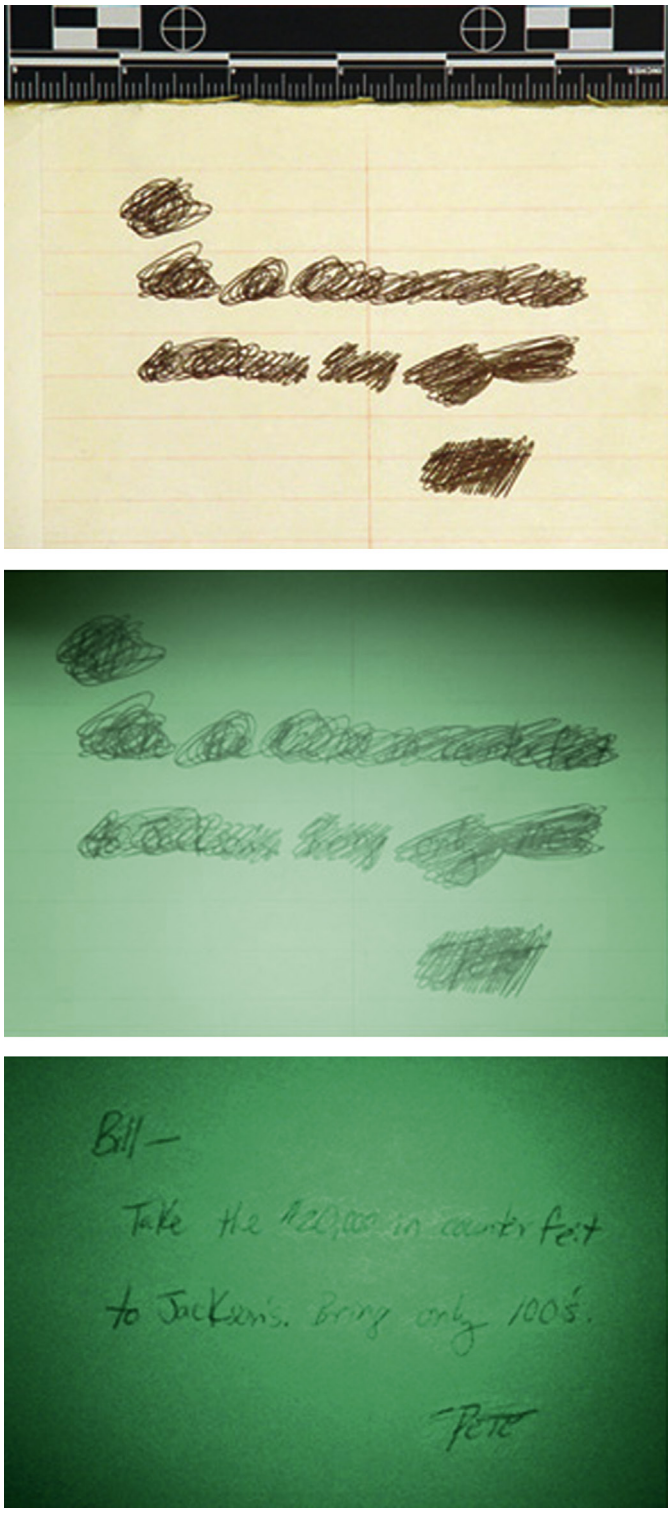


FIGURE 7.30
Obliterated note visualized by infrared.

an ink that absorbs IR light, and the obliteration was written with an ink that goes transparent to IR. The middle image of the three shows the Sony camera's near-IR ability used as is, without the #87 filter. The original writing can be made out, but it is still a bit difficult to see. The bottom image shows the "night shot" capability of the Sony camera with the #87 filter. Impressive!

Actually, IR fluorescence can be created two ways. The more normal technique is to stimulate the inks with a blue/green light. Sometimes that may cause fluorescence in the IR range. More unusual, and less likely, is to stimulate the inks with true IR light and examine the inks in an area further down into the IR range. The lower right image in Fig. 7.26 shows this result.

How is GSR affected by IR light? GSR will absorb IR light, so it will remain dark or turn a bit darker than it originally was, which is unimportant if the surface around the bullet hole is light colored because GSR itself is dark and would be easily seen in this case. If clothing that has a bullet hole in it is very dark or black itself, it will be very difficult or impossible to see the GSR on that type of fabric. The GSR will be darkened by the IR light. Fortunately, however, many black dyes in fabrics reflect IR light. In this case, then, the fabric would lighten to a lighter shade of gray or even white, while the GSR would remain black. Fig. 7.31 shows this effect.

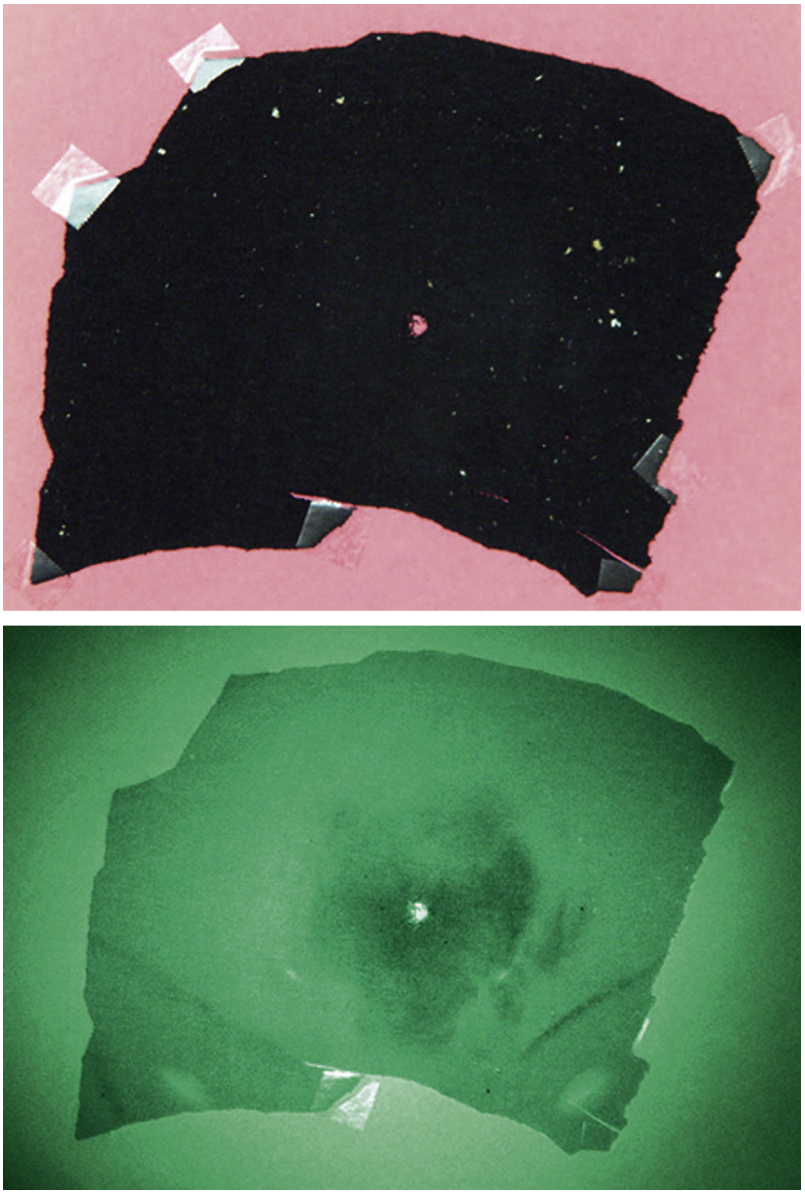


FIGURE 7.31
Infrared Light visualizing gunshot residue on black cloth.

Figs. 7.32 and 7.33 show four shots into the same shirt. They are all examples of reflected IR light, and the images have been converted to black and white for better detail in the GSR against the background. They show the GSR and the bullet swipe as it passed through the shirt, Fig. 7.33 even shows six lands and grooves!

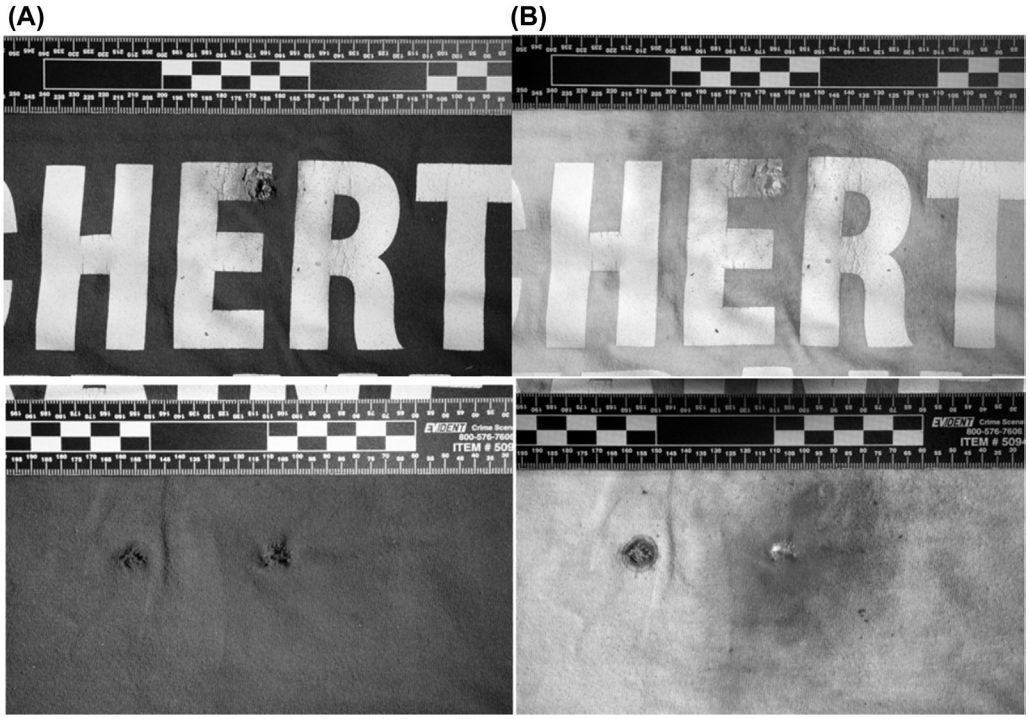


FIGURE 7.32
(A) Normal photograph of T-shirt with two bullet holes. (B) Visualization of gunshot residue on T-shirt with two bullet holes.
Courtesy of King C. Brown & M. Dawn Watkins.

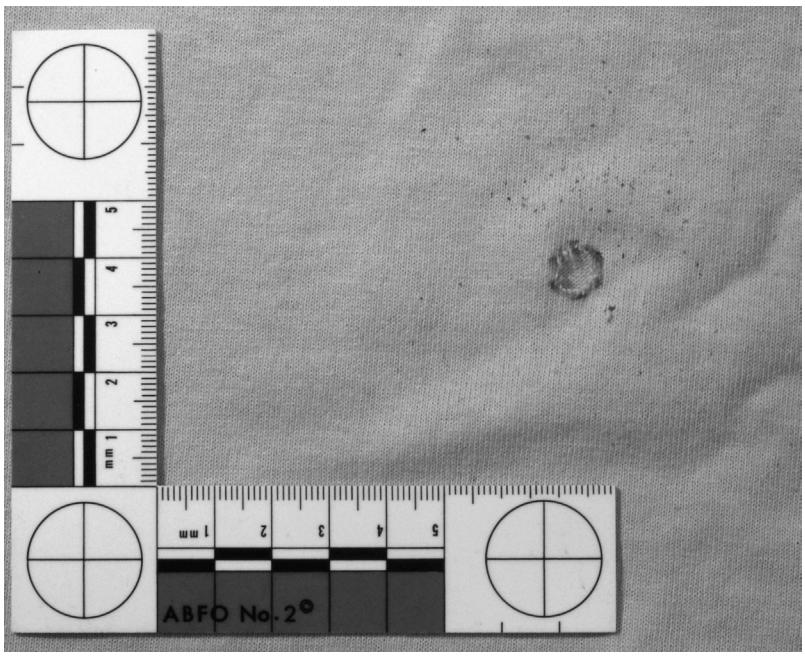


FIGURE 7.33
Visualization of gunshot residue on T-shirt with a bullet hole, displaying six lands and grooves in infrared (IR) from 6″, 40 caliber width, and 87 IR filter.
Courtesy of King C. Brown & M. Dawn Watkins.

It would later be easy for the firearms examiner to determine the range of fire with test shots from the original weapon and with the original ammunition. However, at the crime scene on the night of the incident, this immediately visualized GSR pattern may contradict an alibi being offered by a suspect or a version of the incident being offered by a witness. This would be very important evidence to be aware of. It could help with interrogations and interviews. It could amount to sufficient probable cause to make an arrest. Or, being offered various accounts of what occurred at the crime scene, you could use this information to determine which version of the incident you will believe. If your agency works a substantial number of shooting incidents, having this immediate GSR visualizing capability is invaluable on the day the incident is first reported.

Fig. 7.34 shows the unanticipated result of a GSR transfer to a shirt. The incident in question was a shotgun shooting, where the suspect ran off to the rear of a residential neighborhood. A K-9 was called to the scene to begin a track of the suspect. After tracking just a few houses away, the K-9 "hit" on a dark-blue jersey lying in the grass. Investigators guessed the shirt had been used to wrap around the sawed-off shotgun as the suspect fled. To confirm this suspicion, crime scene photographers decided to examine the shirt with IR imaging to see whether they were lucky enough to have the shape of a sawed-off shotgun transferred to the shirt. When this image was revealed, multiple jaws hit the ground at the same time. The subsequent investigation linked the suspect to another previous shooting with a 0.45 caliber semiautomatic pistol. Sometimes "blind" searches reveal strange types of evidence.

If a suspect does not obliterate an incriminating written document with another pen and ink, another way to eliminate the evidence is to burn it. However, many burned documents are reduced to ash, and if this crumbled ash is the evidence you must deal with, not much can be done. Some papers, however, do not disintegrate into ash when burned. Some paper may just darken and turn black. If this happens, it is similar to the GSR on black fabric. The charred paper may reflect IR light and lighten or turn white. If the ink on the paper is an ink that absorbs IR light, the result will be ink that remains visible because it remains dark. Fig. 7.35 shows an example.

Fig. 7.36 provides another example of IR lighting helping to make reading a partially burned document just a bit easier.

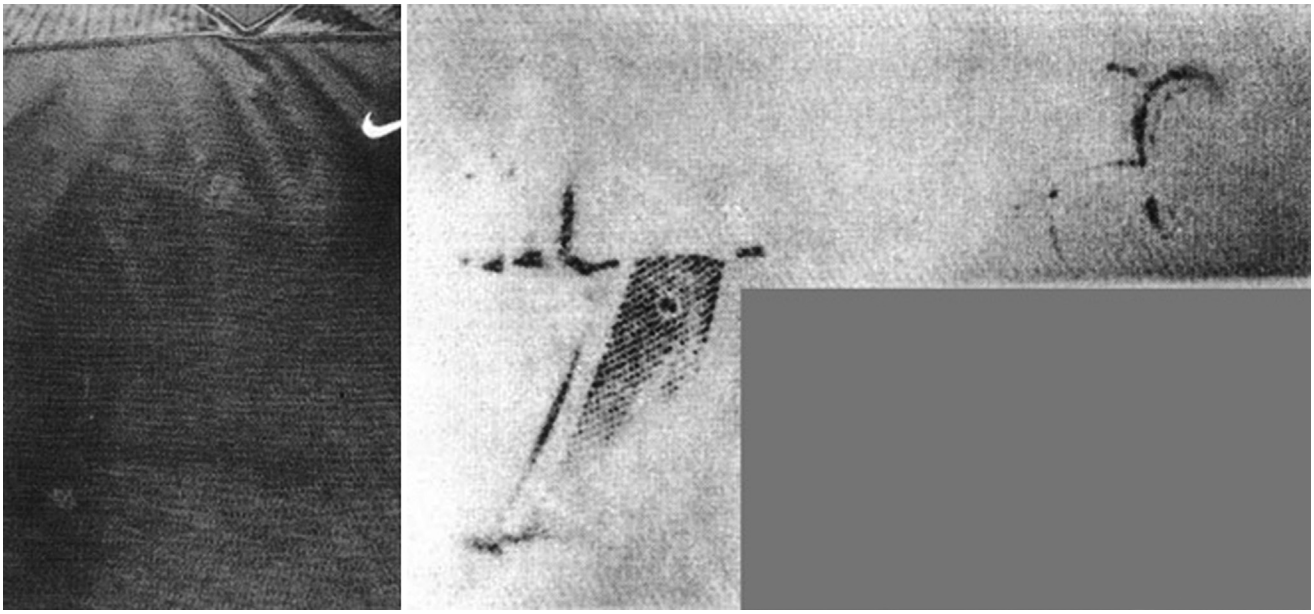


FIGURE 7.34
Infrared visualization of a pistol.
Courtesy Dave Knoerlein, "Digital Dave."

Determining the exposure and the proper focusing point for these IR images was simplified because the camera was sensitive to IR light. Its autofocus properly determined the focus. The camera's meter could determine a proper exposure for IR. Aperture priority exposure mode with an f/8 or f/11 produced acceptable results. Because all the visible light was filtered out with a #87 IR filter, a faster ISO was used.

Tattoo alterations can also be visualized with IR lighting. But, it is always an interesting experiment. One cannot predict how the original inks and the newer inks will react to IR lighting. At least three effects can be anticipated. The original inks may go transparent, showing just the newer inks; the newer inks may go transparent, revealing the original inks; or some of the original inks and some of the newer inks can react the same way to the IR, resulting in a new altered tattoo with just some original and some newer inks remaining. Just because something is visible in IR does not mean it is original ink or newer ink.

Fig. 7.37 is one such example. The colored image is the current tattoo. Is this the original tattoo, or has it been altered in any way? The black-and-white IR version shows changes have been made. In the IR version, additional dark lines can be seen but the colored heart, flower, and the color of the leaf disappear. But, again, because additions are visible in the IR image, the colored image cannot be the original tattoo.

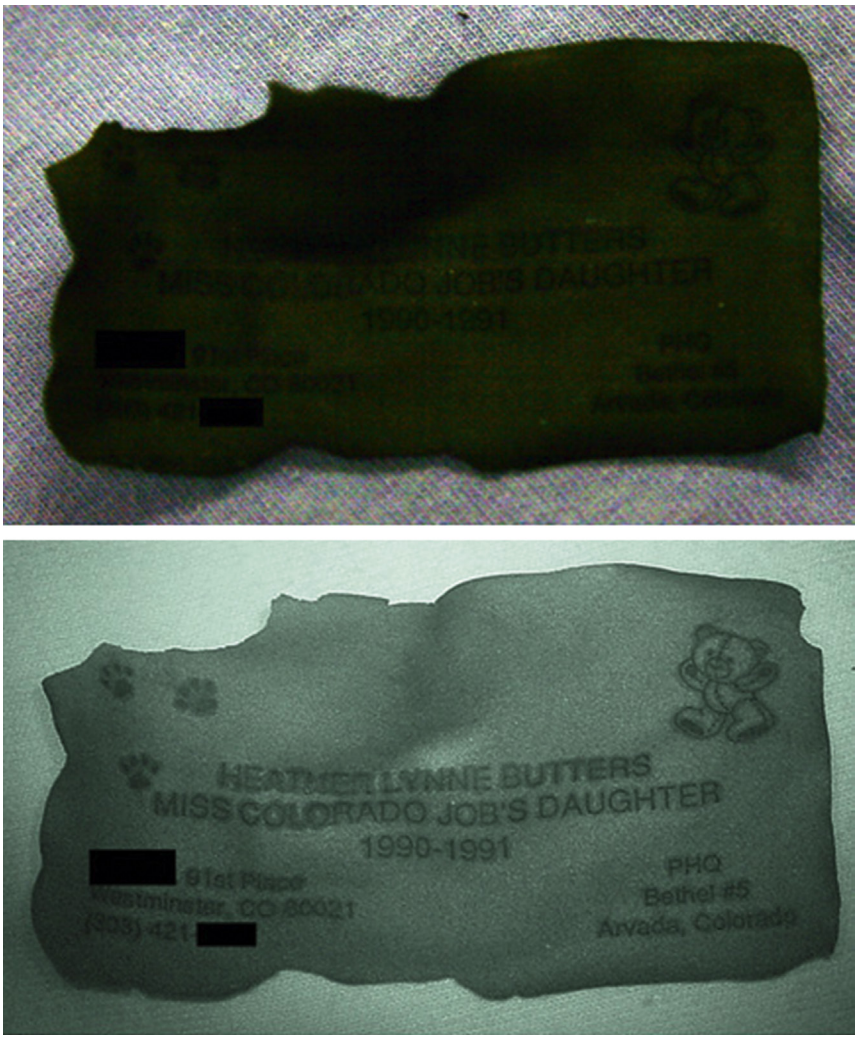


FIGURE 7.35
Infrared visualization of burned document.
Courtesy of GWU MFS student, H. Butters.

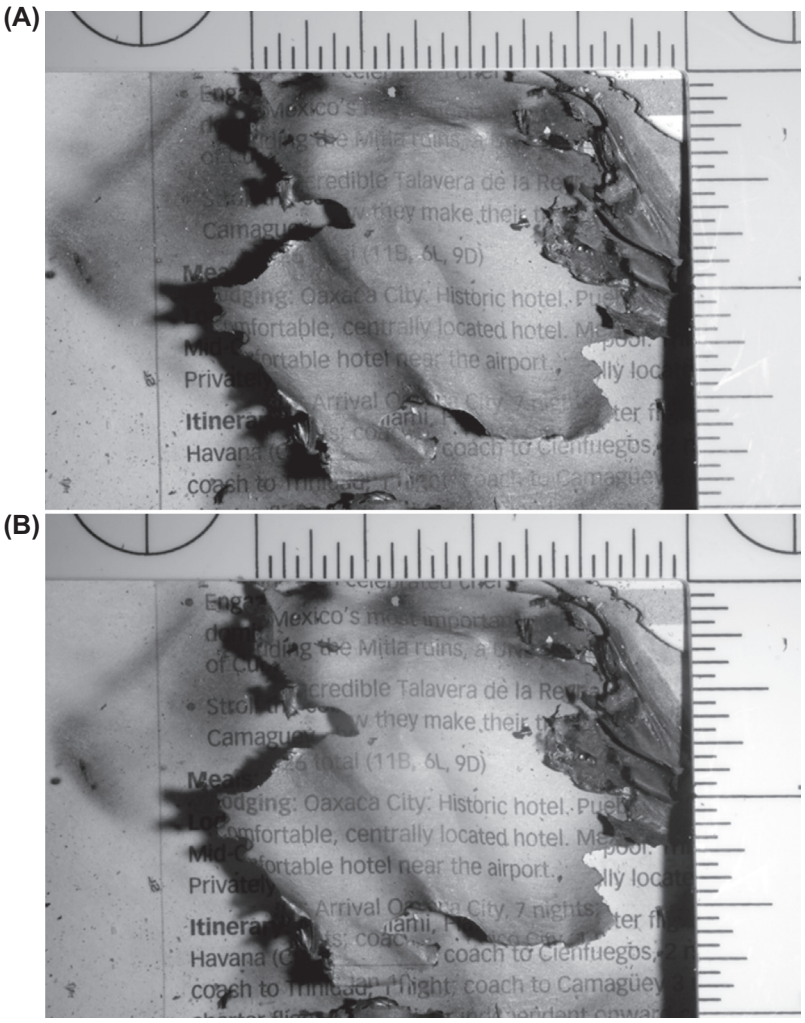


FIGURE 7.36
(A) Normal exposure of burned printing. (B) Visualization of burned printing using an 87 infrared filter.
Courtesy of King C. Brown & M. Dawn Watkins.



FIGURE 7.37
Visualization of tattoo with an 87 infrared filter displaying alterations (left). Visualization of tattoo prior to alterations (right).
Courtesy of King C. Brown & M. Dawn Watkins.

VISIBLE LIGHT FLUORESCENCE

It is possible to create fluorescence in the visible light spectrum in several ways:

- UV light can cause fluorescence in the visible light range. To see or photograph the UV fluorescence, use a UV filter or a yellow filter.
- Emitting a strong monochromatic blue light from either a laser, forensic light source, or an ALS will create fluorescence in the orange part of visible light. The best viewing and photography will be done when using an orange filter.
- Emitting a strong monochromatic green light from an ALS will create fluorescence in the red part of visible light. The best viewing and photography will be done when using a red filter.

Many true ALSs will offer more options than these. Some evidence likes to be fluoresced with one light and viewed through a particular filter. The more options you have and use, the more evidence will be found.

As mentioned previously, fluorescent evidence is not the normal subject that a camera's meter is designed to expose properly. With fluorescence, sometimes much of the field of view will be dark, and one smaller item of evidence may be fluorescing. The camera's meter wants to expose the entire scene properly. If you use the aperture priority exposure mode, use an exposure compensation of −2 and bracket. Even when you are exposing with the manual exposure mode, this tip can be regarded as a Rule of Thumb.

RULE OF THUMB 7.04

When you are photographing fluorescent evidence, the proper exposure is frequently 2 stops less than what the camera's exposure meter recommends. At a −2 exposure compensation, it would then be best to bracket. The camera's exposure meter is designed to provide proper exposures for "normal" scenes, reflecting 18% of the light that strikes them. The fluorescent situation is far from "normal."

In many situations, fluorescent photography will be necessary at crime scenes.

Fluorescent Powders and Chemicals

Some of the most frequently encountered types of fluorescent evidence are fingerprints that have been enhanced and treated with fluorescent powders and chemicals.

Fig. 7.38 shows a variety of fluorescent fingerprint powders, scales, and brushes. Fig. 7.39 shows a collection of fluorescent fingerprints. Fingerprint residues are composed of some chemicals, like riboflavin, which are naturally fluorescent, so it is also possible to notice inherent fluorescence before any treatment. Most fingerprints, however, have to be treated with fluorescent fingerprint powders or liquid dye stains to fluoresce.

Visualizing Nonblood Body Fluids

Another staple of crime scene searches with lasers and ALSs is the search for nonblood body fluids. Semen, saliva, urine, vaginal fluid, and perspiration can all be fluoresced with lasers and ALSs; this can efficiently be done with either a UV light filtered with a UV or yellow filter or a blue stimulating light used with an orange filter. Fig. 7.40 represents some of these fluorescing nonblood body fluids.

Fluorescent Fibers

No crime scene search would be complete without a search for fibers and trace evidence, some of which fluoresce. At times, you will search with the lights on with the naked eye, then with a flashlight, then with a UV light, and finally with a laser or ALS. Many times, different fibers and trace evidence will be found under each of these different lighting conditions. Fig. 7.41 shows a variety of fluorescent fibers.

Drug Residues

Some drugs and the fillers used to increase a drug's volume will fluoresce. Certainly not a positive test for drugs, noticing fluorescence at drug scenes can be helpful, however. If five guys are sitting around a table with a variety of pills and powders scattered about, it is possible these drugs came from one of their pockets. Hit all their pocket areas with a blue light and view the results with orange goggles on, and it is possible the origin of all the drugs may become apparent. Fig. 7.42 shows both a fluorescent crack "sugar cookie" and a homemade pill.

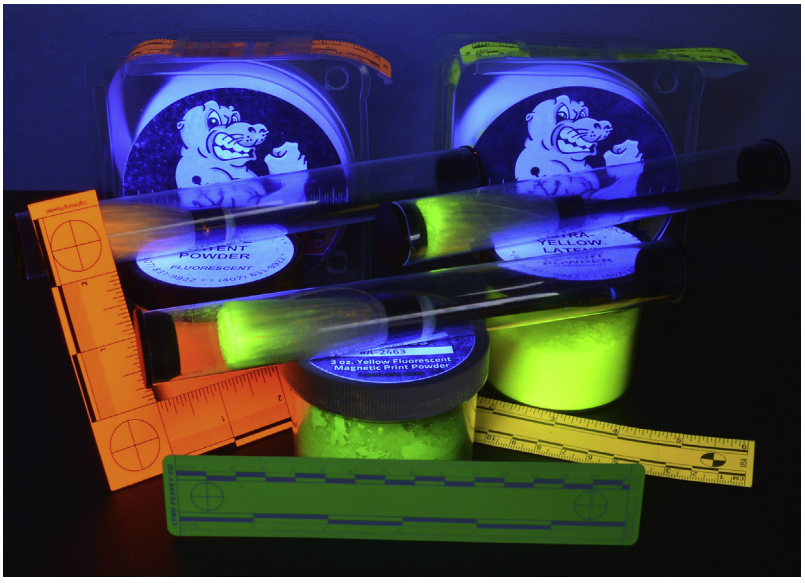


FIGURE 7.38
Fluorescent fingerprint powders, scales, and brushes.
Courtesy of King C. Brown & M. Dawn Watkins.

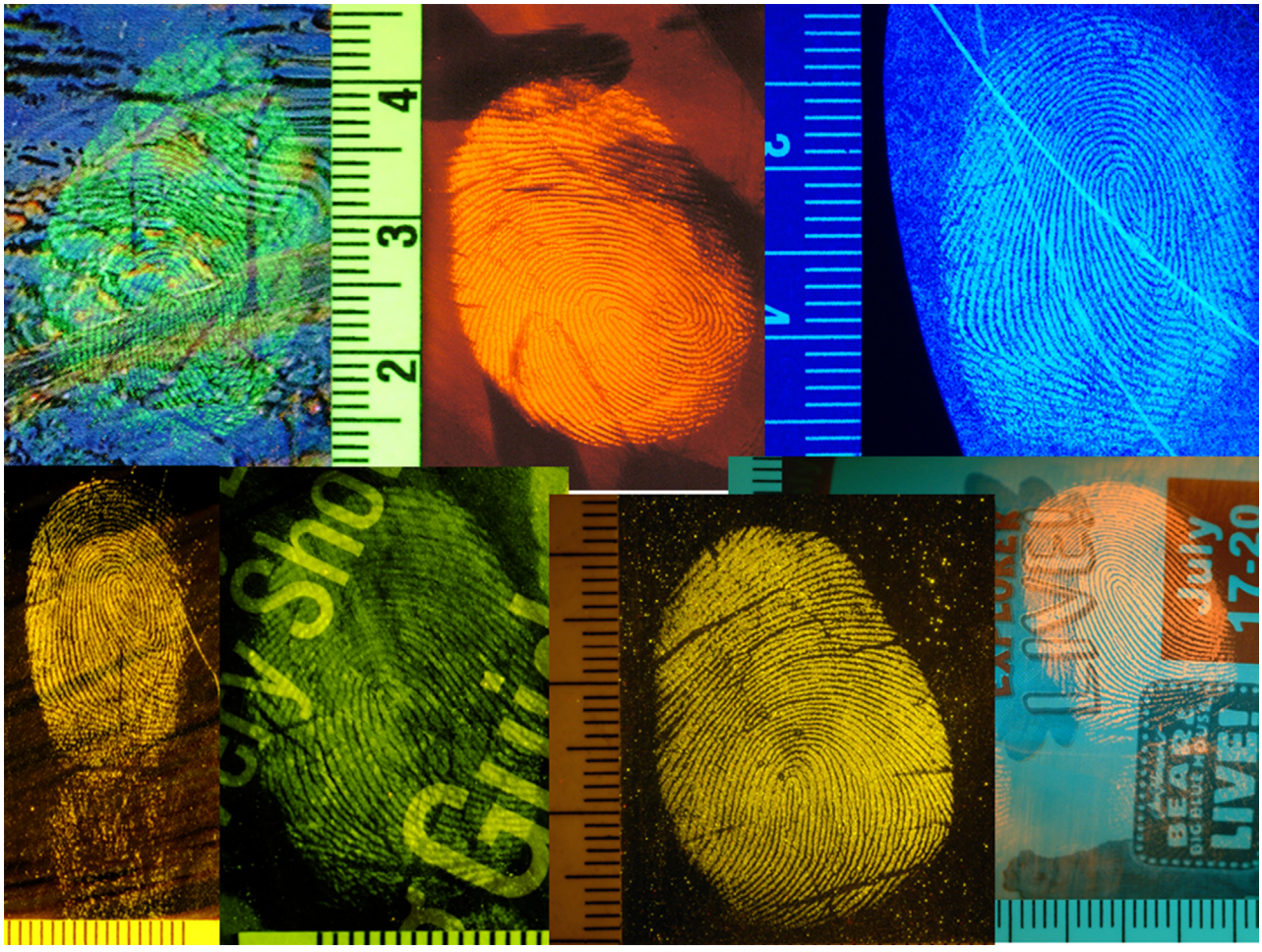


FIGURE 7.39
Fluorescent fingerprints.
Courtesy of King C. Brown & M. Dawn Watkins.

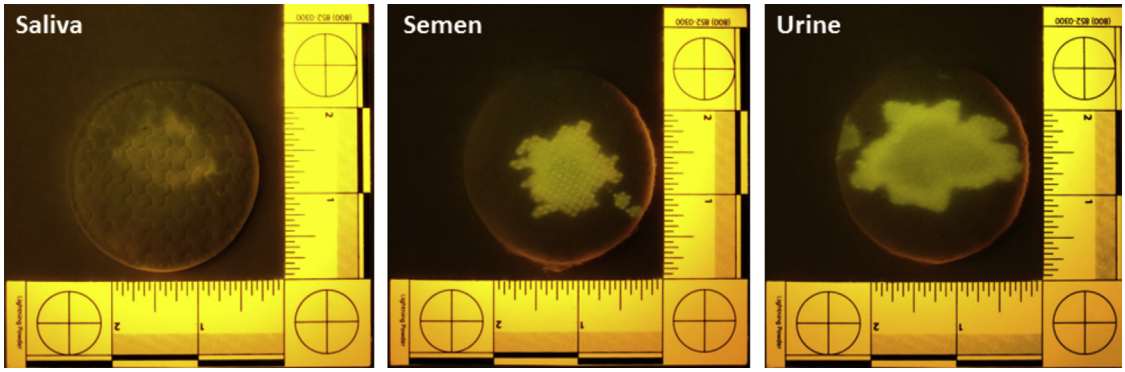


FIGURE 7.40
Fluorescing nonblood body fluids, semen, saliva, and urine.
Courtesy of King C. Brown & M. Dawn Watkins.

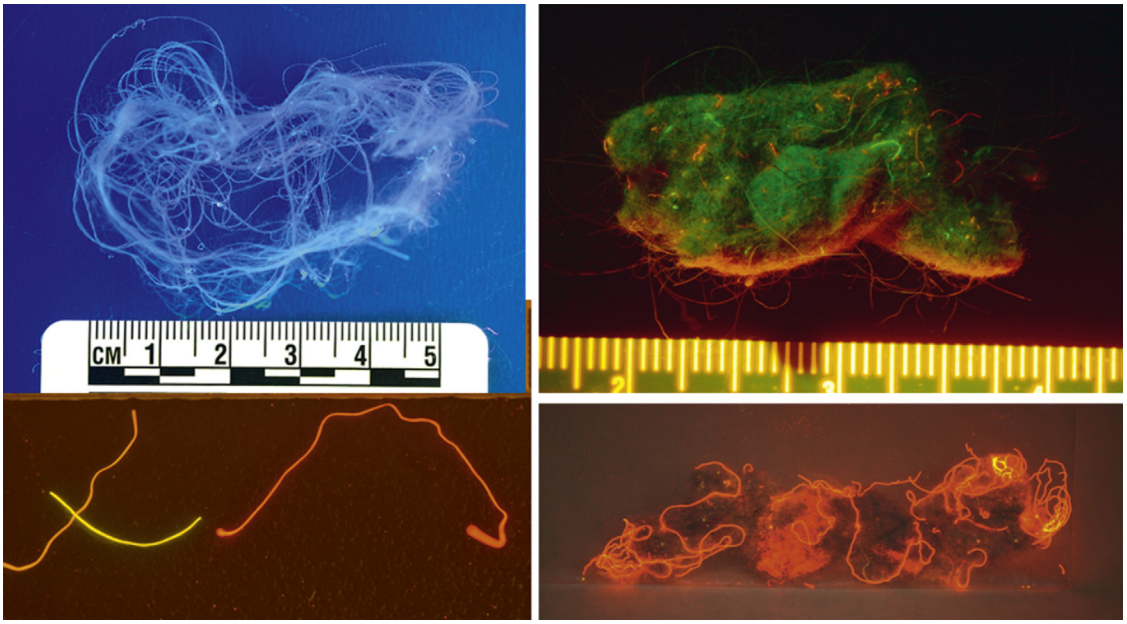


FIGURE 7.41
Fluorescent fibers.
Courtesy of King C. Brown & M. Dawn Watkins.

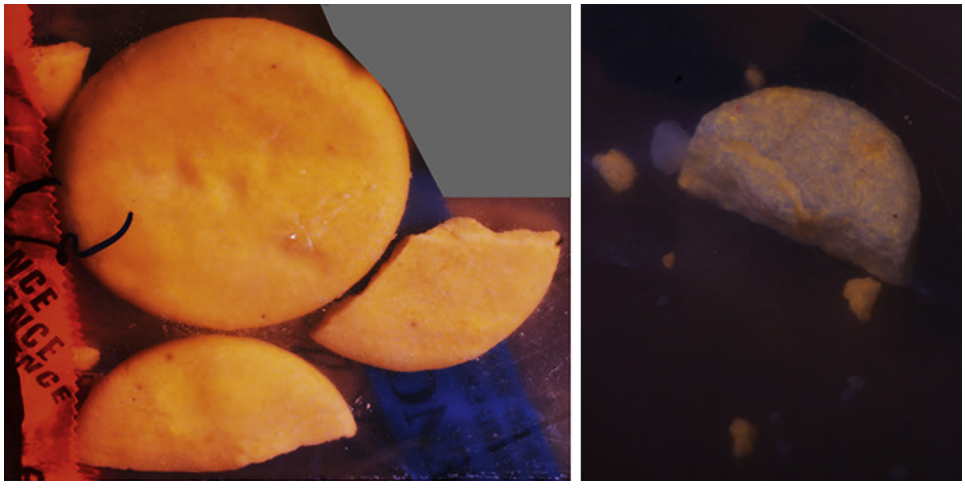


FIGURE 7.42
A fluorescent crack "sugar cookie" and pill.
Courtesy of Tom Beecher, Photografix, Richmond, VA.



FIGURE 7.43
Luminol fluorescing in various dilutions of blood on various substrates.
Courtesy of King C. Brown & M. Dawn Watkins.

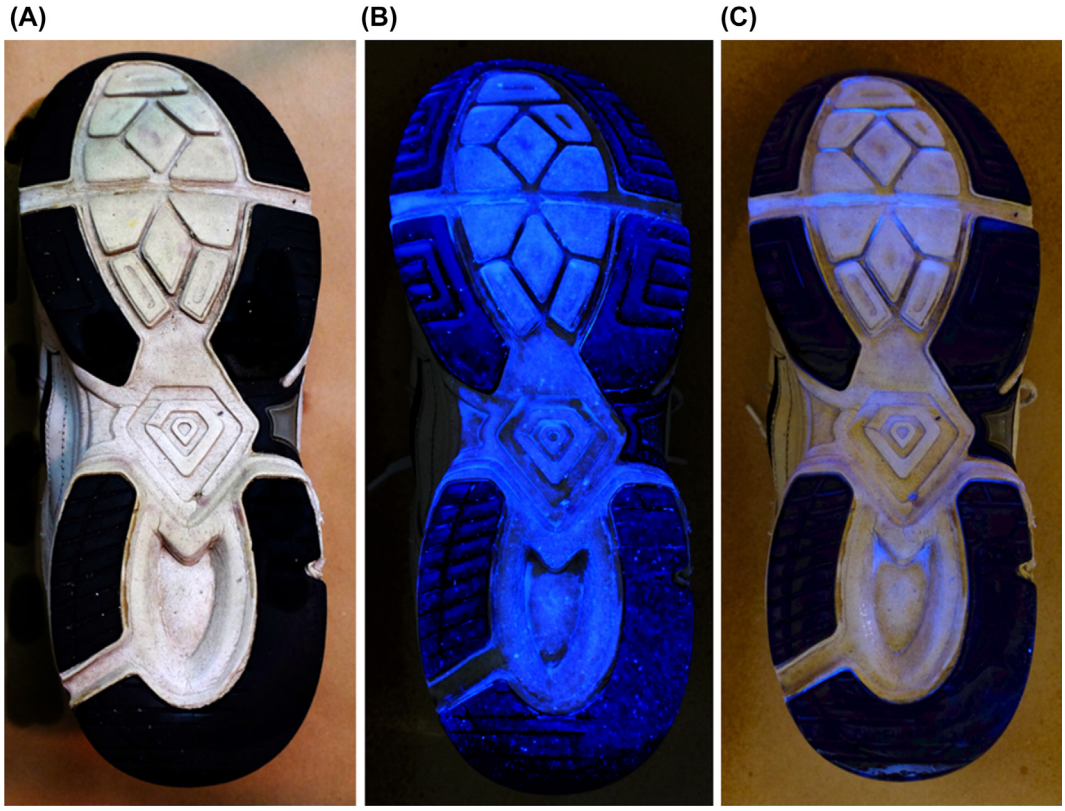


FIGURE 7.44
(A) Cleaned shoe for luminol testing. (B) Luminol fluorescing a shoe sole. (C) Luminol fluorescing a "cleaned" shoe.
Courtesy of King C. Brown & M. Dawn Watkins.

Blood: Luminol, BlueStar, and Leuco Fluorescein

Blood absorbs UV light and gets darker. When chemically treated, blood can also fluoresce. Commonly used to create this chemiluminescence is luminol, a reagent that reacts with the catalase in the heme of the hemoglobin in blood. The literature suggests luminol is extremely sensitive to blood, able to react with blood in dilutions as weak as 1:5,000,000. Fig. 7.43 shows luminol easily fluorescing under various dilutions.

This fluorescing capability makes luminol very useful when you are trying to detect areas where blood has been cleaned up in an attempt to hide a crime. Fig. 7.44 shows two attempts at cleaning the soles of a shoe. The middle shoe was processed with luminol after it had been cleaned. The same shoe was cleaned again, but it still fluoresced with luminol, as the right image demonstrates.

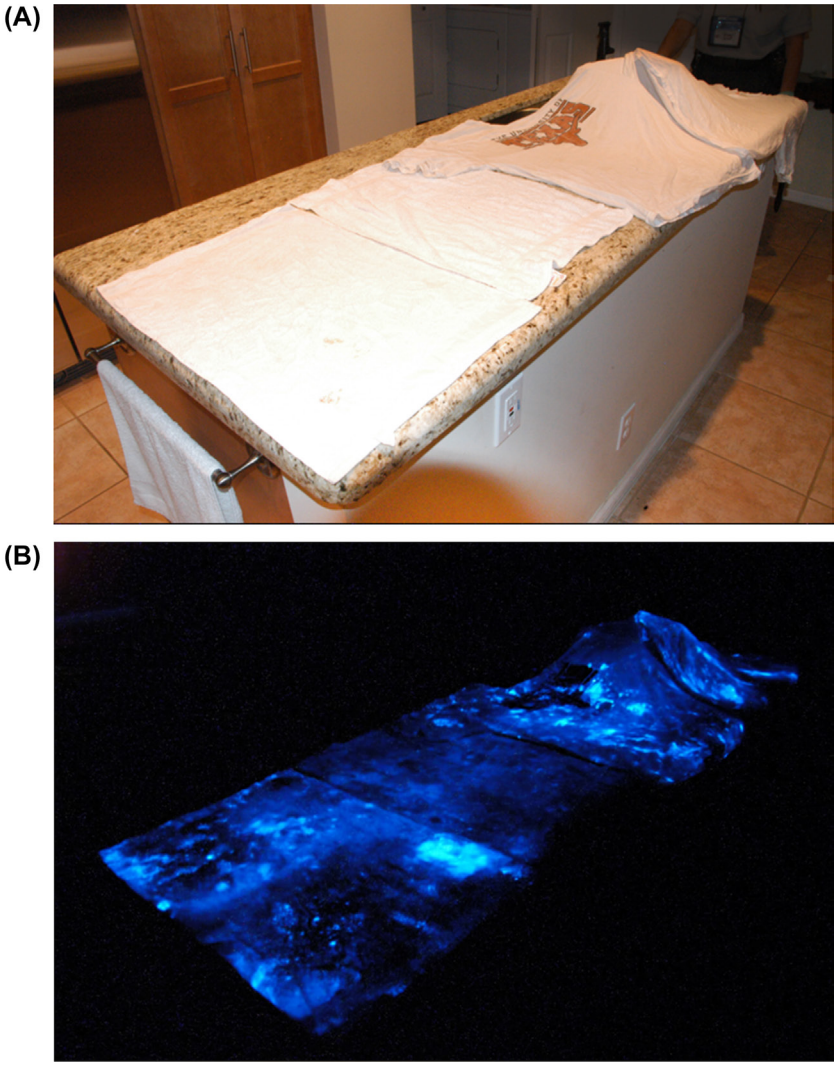


FIGURE 7.45
(A) Normal photograph of machine-washed towels. (B) Luminol visualizing blood from machine-washed towels.
Courtesy of King C. Brown & M. Dawn Watkins.

Fig. 7.45 shows an unsuccessful attempt to hide blood after the cleanup towels were machine-washed. The towels were used in cleaning up a homicide scene. Although the towels appeared to be clean after being washed, luminol revealed the bloodstains remaining on the fabric. Fig. 7.46 shows a student's project to replicate a situation like this. Towels were bloodied and then machine-washed, which appeared to be completely blood free. However, when the towels were subsequently treated with luminol, blood was revealed. Even the original stain patterns could still be visualized.

Another method of hiding blood might be to paint over the stains. Regular household latex paints will not be successful in hiding blood. Fig. 7.47 clearly shows fluorescence, where blood had been painted over by six layers of paint, after the application of luminol. Each square, after the top left square which is whole blood, represents an additional layer of paint over the blood.

The standard recommended exposure for luminol is 400 ISO, f/5.6, and a 90-s shutter speed, with all the room lights turned off and light from outside the room blocked. Two problems exist when fluorescing blood with this exposure, both related to these exposure recommendations.

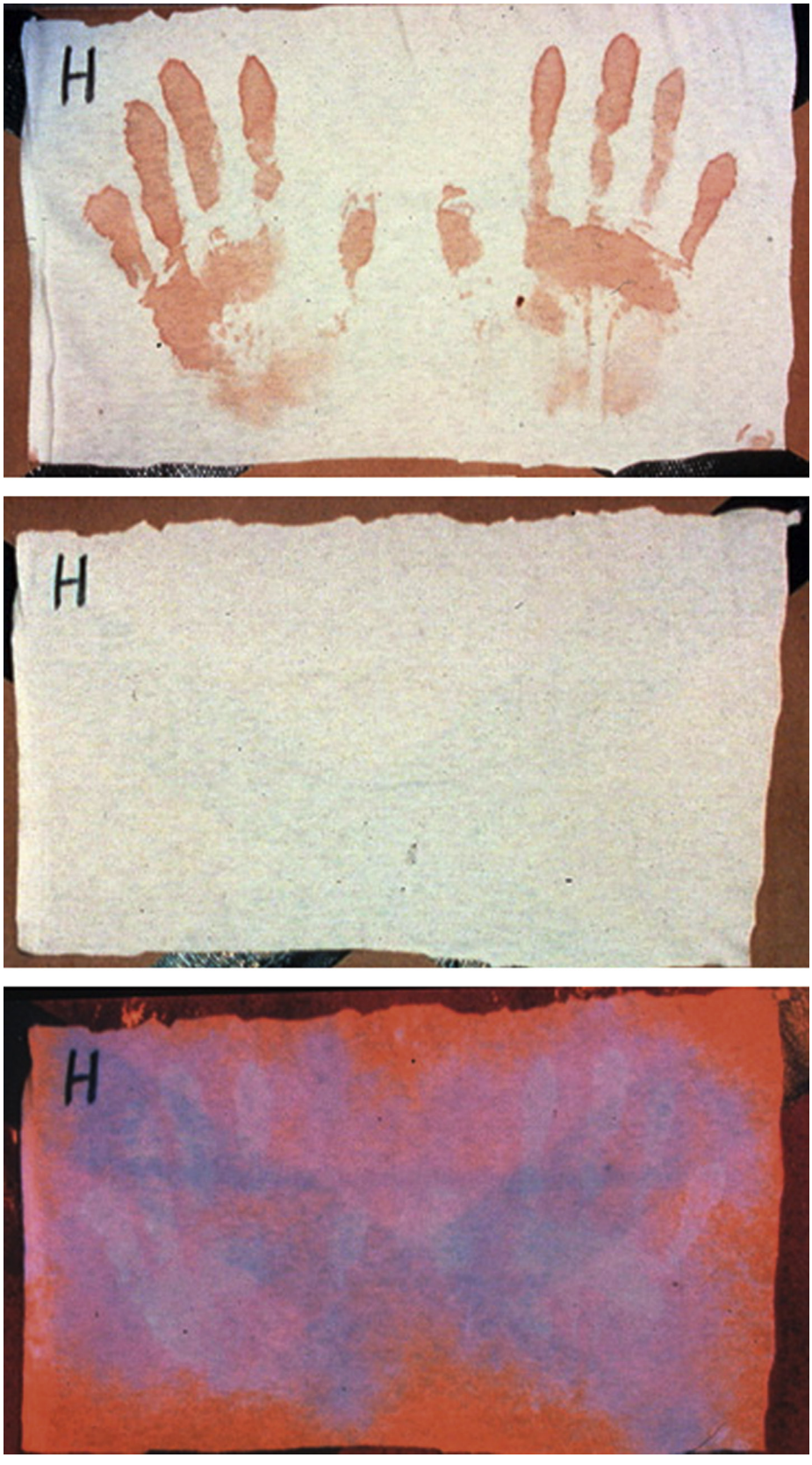


FIGURE 7.46
Bloody cloth, washed in washing machine, and then fluoresced with luminol.
Courtesy of GWU MFS student C. Perletti.

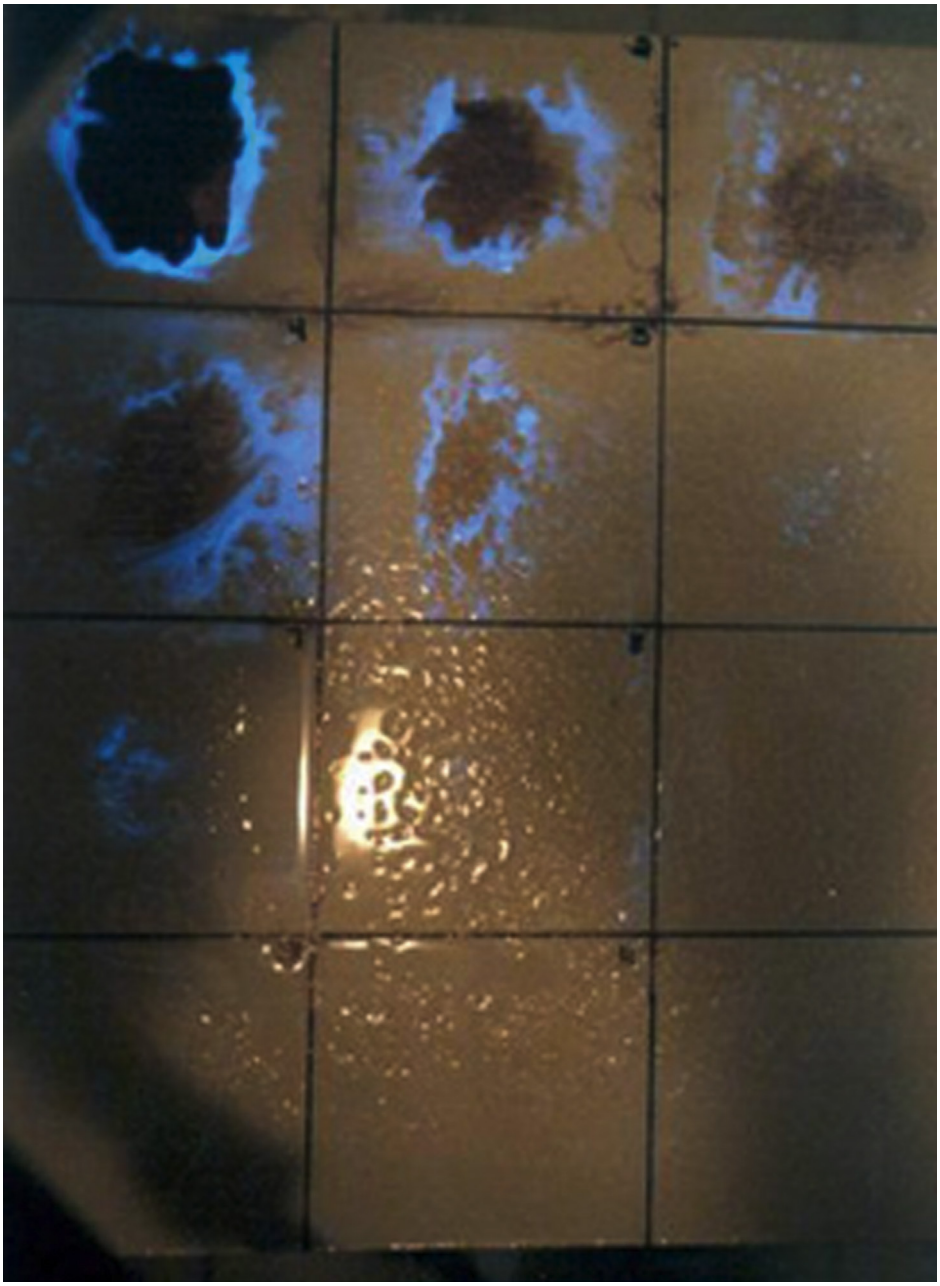


FIGURE 7.47
Blood under various layers of paint still fluorescing with luminol.

First, the 90-s exposure did permit the fluorescence to be photographed, but the rest of the scene appeared to be severely underexposed because no other light was present. Originally, to overcome this known limitation to luminol photography, one photograph was also made with an electronic flash. Then, the two images could be viewed at the same time so the orientation of the fluorescent image could be seen in its context. This need to take two images to allow the fluorescence to be seen in context has been eliminated by recommendations to introduce some form of bounce light during the 90-s exposure. For example, it has been recommended to take a Mag-Light flashlight or Streamlight flashlight and turn it on and off as fast as you can while aiming it at the ceiling above the suspected bloody print. This was done approximately 80 s into the 90-s exposure. This faint bounce light enabled the surrounding area around the bloody fluorescence to also be captured in the same photo. Be sure to never point the flashlight directly at the luminol reaction; it will wash it out.

Fig. 7.48 shows examples of luminol photography without (A) and with (B) a brief bounce light off the ceiling during the 90-s exposure. Now, a single image can show both the fluorescence of bloodstains and the area in which it is found.

If the exposure takes 90 s, more luminol will have to be sprayed over that time frame to sustain the fluorescence. That may be okay with some porous surfaces, but if the surface is nonporous, such an accumulation of liquid may cause the pattern to *run* and become indistinct. Worse yet, if the surface is both nonporous and vertical, like a wall, the bloody pattern will almost definitely run. Five solutions have been offered to counter this problem:

1. Shorten the recommended shutter speed of 90 s to reduce the volume of luminol used. To shorten the shutter speed, you use the concept of reciprocity. If one exposure variable is adjusted to let in less light, another variable must be adjusted to let in more light. Because exposures revolve around halves and doubles, it would be possible to cut the shutter speed in half if the light attributable to the aperture was doubled, and so on. These, then, are reciprocal exposures:
   - 90 s and f/5.6
   - 45 s and f/4
   - 22 s and f/2.8
   - 11 s and f/2

You may be confused by these recommendations. Has not this author taken great pains to recommend against the use of wide apertures? This is certainly true. However, if the fluorescing bloody impression is two dimensional and the sensor is parallel to the impression, the loss of depth of field becomes moot because there is only one plane that will be in focus. Still, wide apertures should normally not be your first choices, which leads us to solution #2.

2. Increase the ISO in proportion to the shortened shutter speed. Changing from 90 to 45 s represents a −1 stop exposure change requiring a +1 exposure change from somewhere. This means changing the ISO to 800. Changing the shutter speed from 45 to 22 s is another −1 stop exposure change, which would require changing the ISO from 800 to 1600. This can be done if, as recommended earlier in this text, you have already done tests with your camera to determine if the digital noise generated with the use of 1600 ISO is acceptable to you.
3. Use a fine mist sprayer. The finer the mist, the less volume of liquid has to be sprayed, and therefore the less running which can occur.
4. Thicken the luminol reagent. A West Coast criminalist, Robert Cheeseman, has suggested thickening the luminol with normal food thickeners like xanthum gum or guar gum. These thickeners can make the luminol so

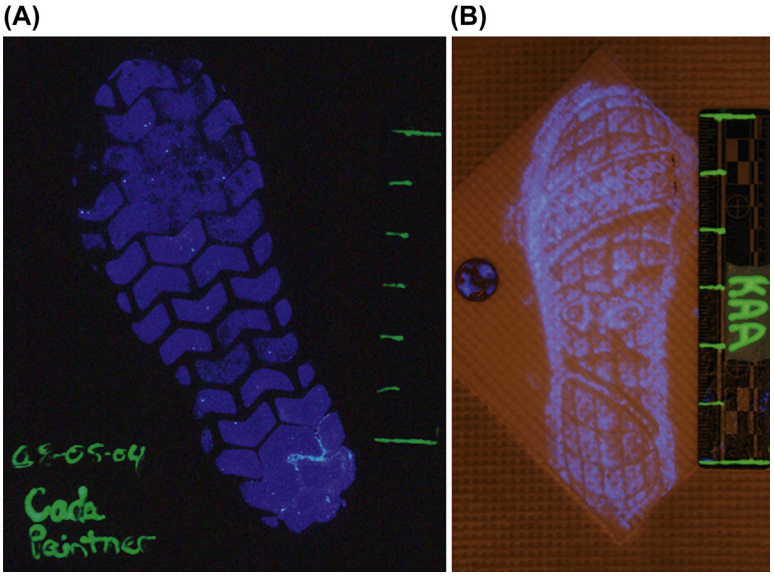


FIGURE 7.48
(A) Blood fluorescing with luminol, but no bounce light *(Courtesy of GWU MFS student C. Painter.)*. (B) Blood fluorescing with luminol and bounce light *(Courtesy of GWU MFS student K. Athenas.)*.

thick that it will not run on vertical surfaces. The problem is that the solution becomes so thick that it has to be sprayed by a high-pressure sprayer rather than just a hand-pump sprayer. But, it works. One enterprising student applied the thickened luminol with a paint roller to a bloody handprint in a shower stall. The luminol nicely fluoresced the bloody handprint, and the pattern never ran down the wall.

5. Fix/stabilize the bloodstain. Another solution to the problem of runny prints on nonporous surfaces is to "fix" the blood with a standard blood fixer like sulfosalicylic acid, which is the common blood fixer used in products like Amido Black and Hungarian Red. The obvious problem is that until the faint bloodstain has been made to fluoresce, you cannot see it, so where should the sulfosalicylic acid be sprayed? You might ask, "Why not just combine the luminol and sulfosalicylic acid into one reagent?" The problem is that neither works as effectively when mixed together. However, experiments have shown that at a ratio of 3:1, the luminol:sulfosalicylic acid combination reagent both fixes the blood and still fluoresces it nicely.

Besides washing a bloodstained area with just soap and water, the use of bleach may also be used. To the criminal, this may represent a double benefit. It helps to clean up the bloodstain, and it is hoped the use of bleach also prevents subsequent DNA analysis of the blood. So, how does bleach react to luminol? Fig. 7.49 shows that bleach will fluoresce much more brightly than blood. The bleach will seem to "sparkle" at times. Blood usually fluoresces a dull blue. You may see a combination of dull blue and an area fluorescing very brightly. If one wants to try to collect a sample of blood for subsequent DNA analysis, try to swab the areas fluorescing a dull blue.

Fig. 7.50 is another example of blood and bleach fluorescing side by side, and it may look familiar. This is the image which was modified to help create the cover of the second edition of this text.

Speaking of cleaning up a bloodstained scene, keep on the lookout for attempts to clean up very specific areas, in some cases, weapons. Fig. 7.51 shows an attempt to clean blood from both sides of a knife with a towel. You may find some interesting patterns with luminol. One pattern we should always be looking for is the path of travel of a suspect after having stepped into blood. Not only does it possibly provide a shoe print pattern, but it also provides a direction in which other evidence may be found. In order to photograph an image like Fig. 7.52, one has to be prepared to run alongside these prints, spraying each and moving to the next during a long shutter speed. Each shoe print may need to be resprayed as it begins to dim during the long exposure. In a situation like this, it is also necessary to use an exposure combination which favors the use of smaller apertures and faster ISOs rather than wider apertures as recommended earlier in this chapter. The depth of field from the smaller apertures is required to have all these shoe prints be in focus.

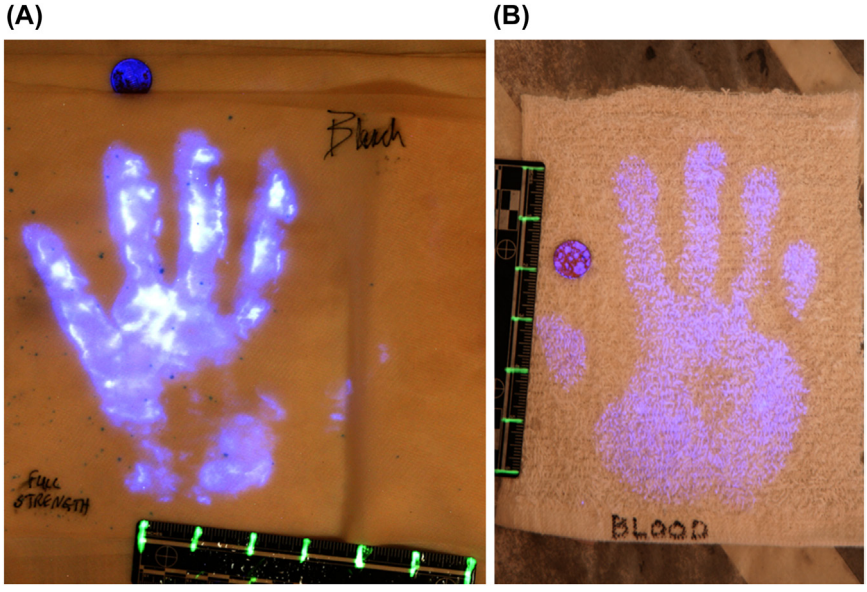


FIGURE 7.49
Bleach (A) and blood (B) fluoresced with luminol.

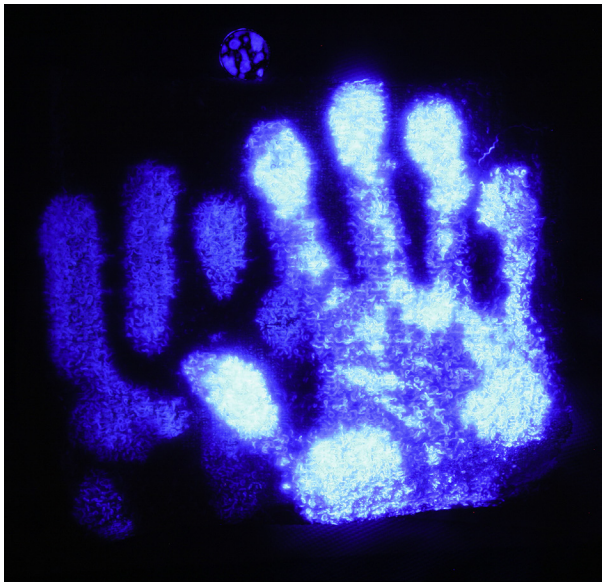


FIGURE 7.50
Bleach (right) and blood (left) fluoresced with luminol.

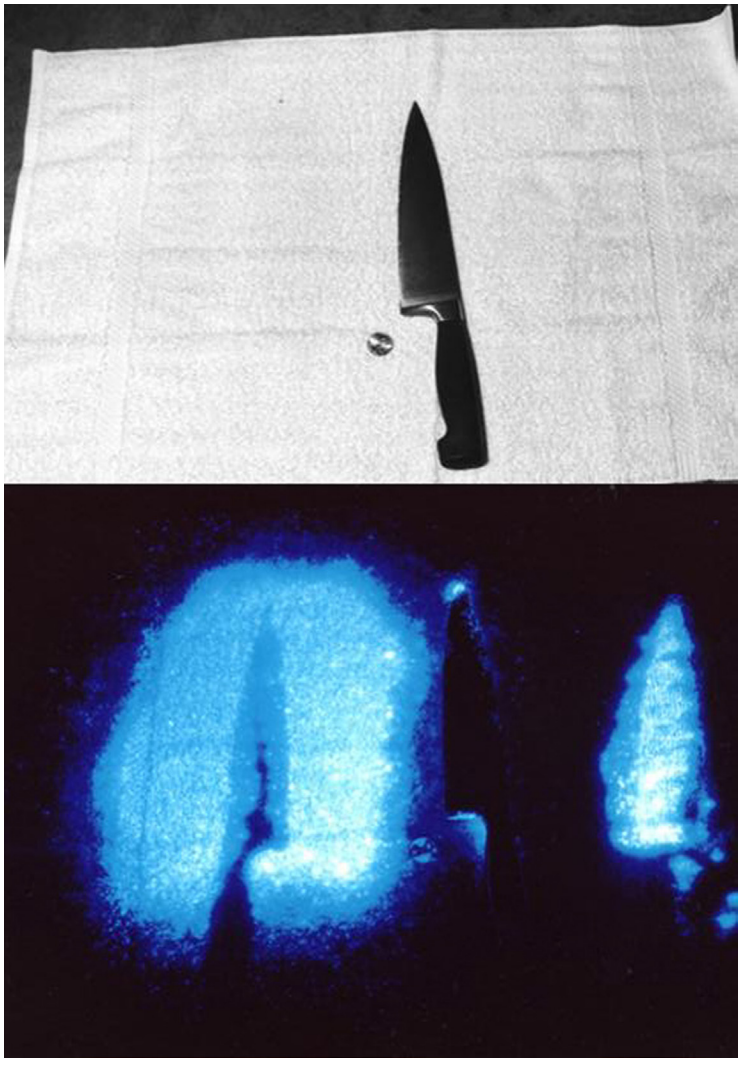


FIGURE 7.51
Luminol fluorescing a bloody knife wiped on a towel.

A couple of alternatives to luminol exist. Both BlueStar and leuco fluorescein are chemistries used to cause faint bloodstains to fluoresce. Their advantage is that they create a brighter fluorescence than luminol, and the fluorescence lasts longer than the brief luminol fluorescence. Each, however, has a disadvantage. Leuco fluorescein requires an ALS to stimulate the fluorescence; the fluorescence does not come from a chemical reaction with the blood. Use a blue light with an orange filter to stimulate leuco fluorescein. BlueStar, though living up to its claims of a brighter fluorescence over a longer time period, is substantially more expensive than luminol.

The advantage of having a brighter, longer-lasting fluorescence, nevertheless, is a great one. Leuco fluorescein can cause the same item previously treated with the reagent to fluoresce several months later when lit with an ALS again. Figs. 7.53 and 7.54 show the fluorescence caused by leuco fluorescein.

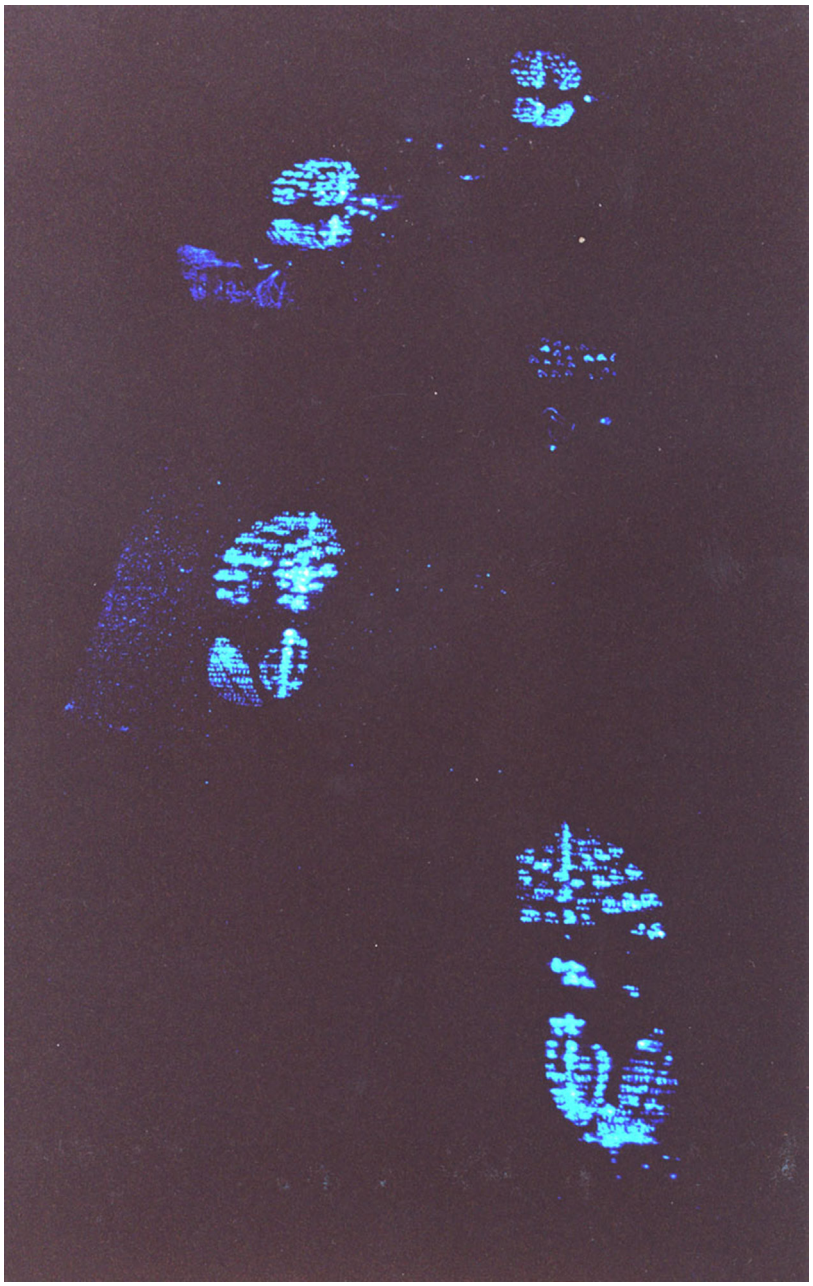


FIGURE 7.52
Bloody shoe prints fluoresced with luminol.



FIGURE 7.53
Bloody shoe print fluoresced with leuco fluorescein.

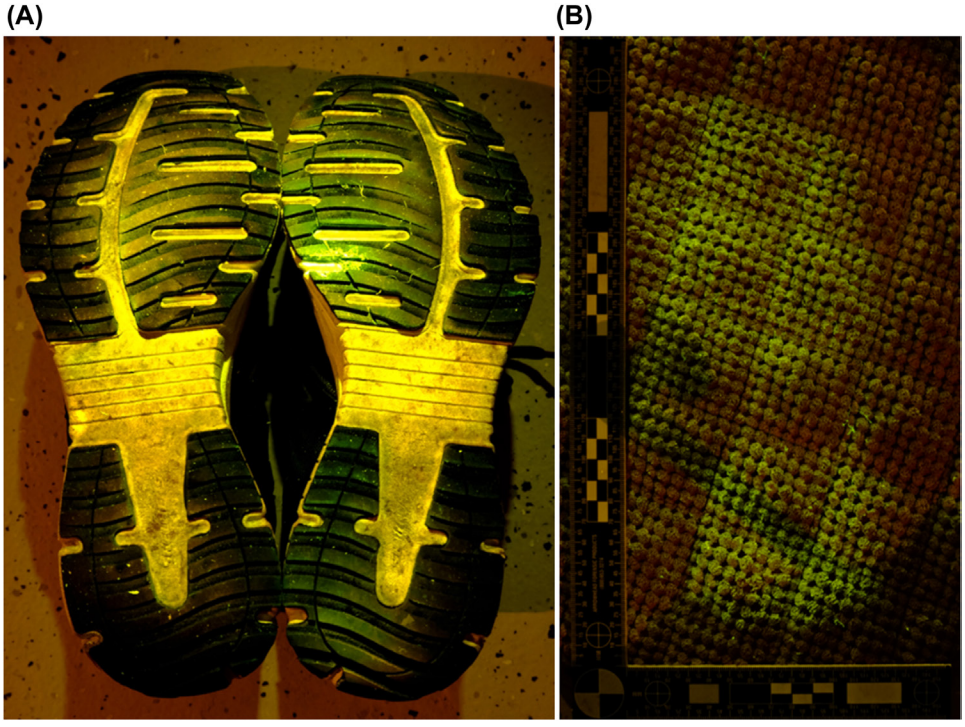


FIGURE 7.54
(A) Leuco fluorescein visualizing bloody shoes. (B) Leuco fluorescein visualizing faint bloody shoe print.
Courtesy of King C. Brown & M. Dawn Watkins.

Because BlueStar fluoresces so brightly, it is not necessary to work in a dark environment when photographing the resulting fluorescence. Fig. 7.55 shows the use of BlueStar on a vehicle in a garage with the lights on at the time.

False reactions with bioluminescent chemicals are primarily caused by plant peroxidases, metals, chemical oxidants, and catalysts (bleach). Fig. 7.56 shows the bleach and blood reactions to BlueStar. Noticing the typical bleach reaction to luminol and BlueStar at a crime scene can confirm that someone has taken some effort to clean up the area. Look around the entire area. Take swabs from those areas exhibiting the duller fluorescence of possible blood.



FIGURE 7.55
BlueStar photo of a vehicle and natural light photograph.
Courtesy of Neil Zielinski, Palm Beach County Sheriff's Office, Florida.



FIGURE 7.56
Traditional luminol photo of a floor drain with bleach to display a false-positive reaction.
Courtesy of Jose Rosales, Hallandale Police Department, Florida.

Fluorescence of Bone

Although this need does not arise frequently, you should know that bone fragments can also fluoresce, and if the issue is a search of a wide area for bone fragments, the use of an ALS will simplify the search. This effect is visualized by stimulating the search area with a blue forensic light, and observing and photographing the results with an orange pair of goggles and an orange filter on the lens. Fig. 7.57 shows a fluorescent bone fragment mixed in with gravel and debris. The use of long-wave UV can also fluoresce bone fragments: see Fig. 7.58. An ALS set to 365 nm was used for both of these bone fragments.

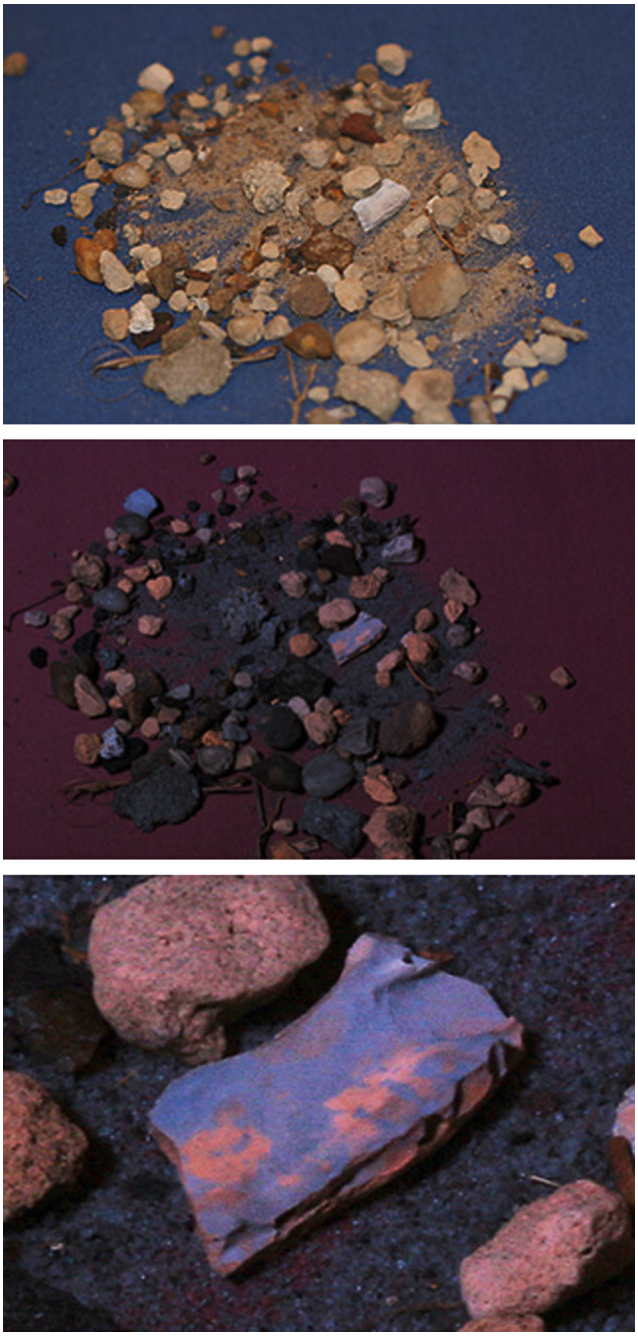


FIGURE 7.57
Fluorescent bone fragments.
Courtesy of Tom Beecher, Photografix, Richmond VA.

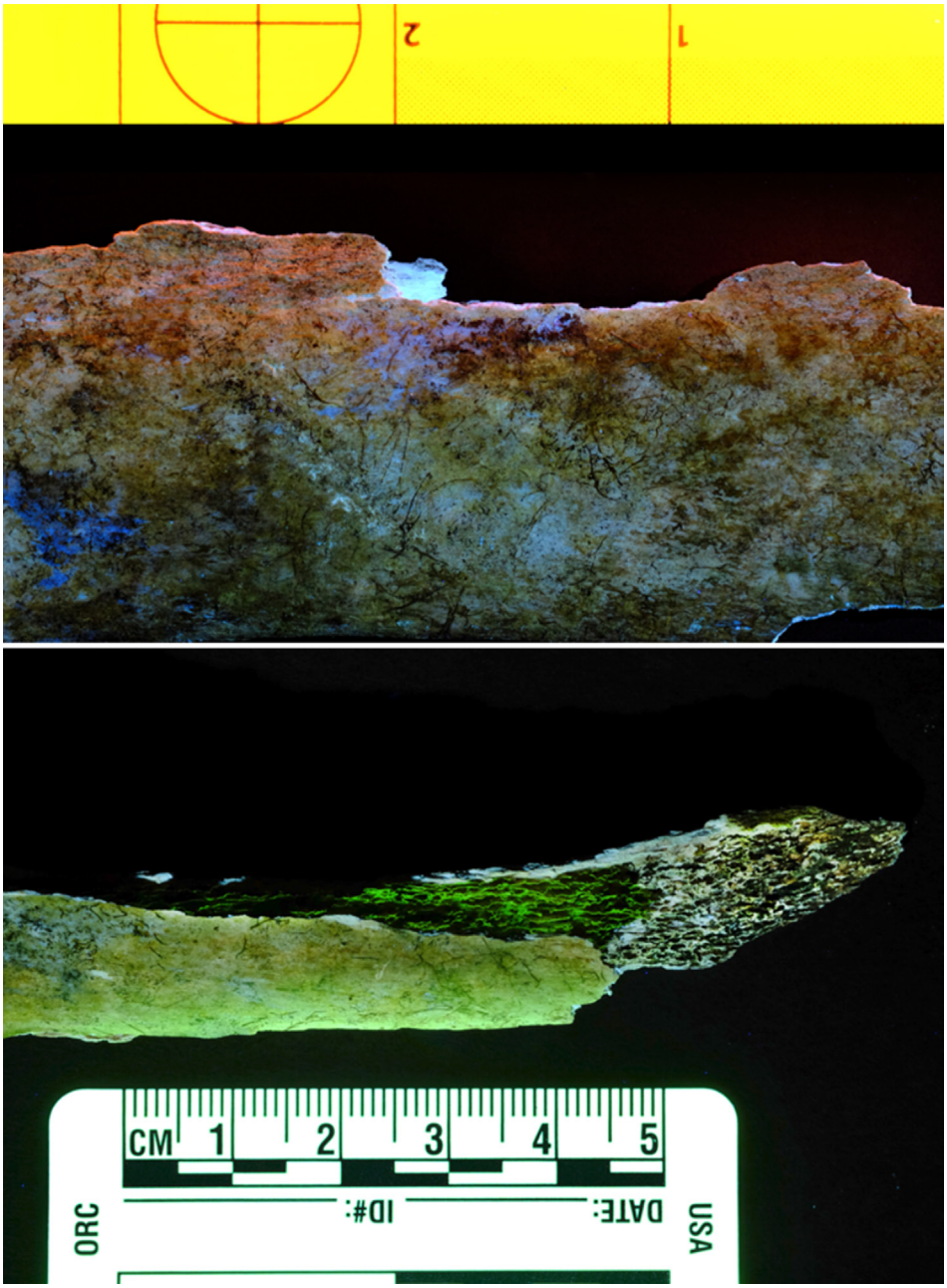


FIGURE 7.58
Fluorescent bone fragments.
Courtesy of King C. Brown & M. Dawn Watkins.

Because of latent fingerprints, crime scene photographers are all aware that evidence may be present at a crime scene that is currently not visible, but this is not just limited to fingerprints. Many other types of evidence are currently not visible but can be made visible by use of the proper techniques. With the use of lighting in other than the visible light range, more of what is available can now be seen and collected as evidence. You just have to learn to "see" in different ways.

LEARNING OBJECTIVES, REVISITED

The light that is the foundation of photography is related to the EMS. This spectrum depicts light as a wave of radiation, which has a peak height (amplitude), a distance between peaks (wavelength), and a number of complete waves passing a point each second (frequency). When light strikes various surfaces, it can interact with those surfaces differently, and crime scene photographers can use these differences to visualize otherwise "invisible" evidence.

UV light can be used to search for faint bloodstains, tracks, or trails. UV light can also cause nonblood body fluids, some fibers, and some fingerprints to fluoresce. The evidence can then be photographed while fluorescing and collected.

IR light can also react differently to different substances and substrates, making it possible to visualize various types of evidence not noticed in the visible light range. Inks with different chemical makeup can frequently be distinguished, and GSRs on dark fabrics can more easily be seen. Printing or writing on charred documents can sometimes be visualized by use of IR lighting techniques. Some inks can be made to fluoresce in the IR range when stimulated with blue–green light.

Many types of evidence can be made to fluoresce in the visible light range of the EMS, enabling the evidence to be seen, photographed, and then collected.

DISCUSSION QUESTIONS

1. Explain the relative location on the EMS of UV light, visible light, and IR light.
2. How is fluorescence related to the Stokes shift?
3. Light can behave differently when striking various surfaces and substrates. What are these different effects?
4. What are some positive and negative aspects of using UV light at crime scenes to locate and visualize evidence?
5. Discuss some of the advantages of having IR imaging capabilities at major crime scenes.
6. Discuss some of the types of evidence that can be visualized with the use of ALSs.
7. Using ALSs, UV light, and IR light at a crime scene also requires using the appropriate filters or goggles. Which filters or goggles are required for these different light sources?

EXERCISES

Obviously, having access to an ALS, UV light, and IR light, along with the appropriate filters and goggles, is essential for the following exercises. Protective eye wear should be used at all times when working with these light sources. Working with blood and body fluids poses its own health risks. Proper precautions should be exercised when working with blood and body fluids.

1. Photograph a close-up of a fluorescing fingerprint. Dust a fingerprint with fluorescent powder and a feather duster. Be careful not to overpowder the print. With the camera on a tripod, use aperture priority, f/11, the ALS emitting blue light, and an orange filter on the lens. Include a partial fluorescent scale with your initials on it. Bracket with a –1 and –2.
2. Photograph a close-up of a fluorescing fiber. You may be successfully finding a fluorescent fiber by collecting lint from a dryer and examining it with a UV or ALS. With the camera on a tripod, use aperture priority, f/11, the ALS emitting blue light, and an orange filter on the lens. Alternatively, a long-wave UV light and yellow filter can be used. Include a partial fluorescent scale with your initials on it. Bracket with a –1 and –2.
3. Photograph a fluorescing nonblood body fluid. This may be semen or saliva. Not all saliva stains fluoresce readily, so several may have to be checked. Semen readily fluoresces. Use the camera on a tripod, aperture priority, f/11, the ALS emitting blue light, and an orange filter on the lens. Alternatively, a long-wave UV light and yellow filter can be used. Include a partial fluorescent scale with your initials on it. Bracket with a –1 and –2.
4. Photograph a bloody shoe print or handprint with luminol. This can be animal blood. Bleach may be used as a blood substitute. Photograph in complete darkness, with a flashlight briefly bounced off the ceiling during the exposure. A phosphorescent scale with phosphorescent initials can be included, as well as a penny and positive blood control. Exposure: use the camera on a tripod, ISO 400, f/5.6, 90-s SS (45 s for bleach as a blood substitute); or a reciprocal exposure.
5. View various black inks in IR light through an IR filter (#87) to determine those that absorb IR and remain dark, and those that transmit IR and go invisible. With an ink that absorbs IR light, write your name. With an ink that transmits IR light, obliterate your name by scribbling over it until it cannot be read in visible light. Photograph the obliteration in ambient light or with a flash.
6. Using a digital camera with IR sensitivity and an IR filter on the lens, project IR light on the obliteration and photograph your name "through" the obliteration. Include a labeled scale, ensuring the ink you use on the label remains visible under IR light.
7. Photograph a piece of black cloth that has been shot at between a 3″ and 8″ range. Use ambient light or a flash.
8. Photograph the same piece of cloth, but image with IR light and an IR filter over the lens. Include a labeled scale; ensuring the ink you use remains visible under IR light.

9. Create a diluted animal bloodstain on a fabric with a busy background pattern. Photograph in ambient light or with an electronic flash.
10. Using a long-wave UV light, the stain should absorb the UV light and appear to turn darker when viewed in the visible light range without any filters. Photograph with the camera on a tripod, aperture priority mode, and f/11.
11. Compare your images with those in this chapter and with other images on the Companion Website (http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646), referring particularly to the following image folders: Fluorescent, Infrared, and Luminol.

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CHAPTER 8

Photogrammetry

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Chapter Outline

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Key Terms
Natural Grid
Perspective Grid
Photogrammetry
Reverse Projection
Rhino Photogrammetry

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the meaning of the general term "photogrammetry";
2. Explain the methods used to extend a perspective grid over the evidence within a crime scene; then, once the grid has been extended over the crime scene, explain how the grid is reduced around each item of evidence until the precise location of the evidence can be determined in relation to the grid itself;
3. Explain how the perspective grid itself is spatially related to the crime scene;
4. Describe the perspective disc variation in relation to the perspective grid technique;
5. Explain when neither grids nor discs are necessary to do photogrammetry and explain when the natural grid variation will be able to be used to determine the precise measurements of evidence;
6. Explain the reverse projection photogrammetry variation;
7. Explain the basics of rhino photogrammetry.

INTRODUCTION TO PHOTOGRAMMETRY

Adequately documenting a crime scene normally requires three activities. Of course, the crime scene must be photographed. The crime scene and the evidence within it also have to be measured, and sketches and finished crime scene diagrams have to be drawn. This can be done by hand, the old-fashioned way, or a variety of computer-aided diagramming software programs can be used. Finally, taking meticulous notes is required. All three crime scene documentation methods complement each other; with all three, every aspect of the crime scene has been fully documented. No one method of crime scene documentation can suffice. This is a very time consuming, but necessary, process.

Would it not be nice if one of these "necessary" steps could be eliminated? In particular, do we still have to use a tape measure to gather the measurements of the crime scene itself and the evidence within the crime scene? Can a way to streamline the process be found? If nothing is lost along the way, an increase in efficiency is always desirable, is it not? This is a pretty strong suggestion: suggesting eliminating the process of taking crime scene measurements. That is

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not this author's intent. Confident that the techniques in this chapter produce measurements just as accurate as can be derived by use of traditional measuring of the crime scene with a tape measure, this author still regards **Photogrammetry** as a supplement to the traditional baseline coordination and triangulation measurement techniques.

This author has taught photogrammetry at the Virginia Forensic Science Academy, the Northern Virginia Criminal Justice Training Academy, and on campus at The George Washington University (GWU). During their first exposure to photogrammetry, all three types of students usually end up quibbling about fractions of an inch when the known answers are provided to the problems they have worked. To be sure, there are some very sophisticated variations of photogrammetry: aerial and satellite photogrammetry applications to mapping and image analysis. The FBI uses complex software to extrapolate the height of bank robbers and the lengths of sawed-off shotguns used in the commission of crimes. On the other end of the continuum, however, there are some very basic applications of photogrammetry that can easily be understood and applied to crimes scenes. This marriage of crime scene photography and the need to acquire accurate measurements of the evidence within crime scenes is the essence of photogrammetry.

The term "photogrammetry" refers to the activities of "(1) photographing an object; (2) measuring the image of the object on the processed photograph; and (3) reducing the measurements to some form such as a topographic map (Moffett and Mikhail, 1980, p. 1) or a scale crime scene diagram."

More simply, we might say that photogrammetry is "the science or art of obtaining reliable measurements by means of photographs" (Slama, 1980, p. 1). Photogrammetry is the method, for example, by which the moon has been mapped. Surveyors did not scout the surface of the moon. The measurements of the moon's surface were derived by the analysis of photographs of the moon.

We are all familiar with a checkerboard or a chessboard: a neat 8 square × 8 square combination of rows and columns. Many floors are made up of 1′ × 1′ floor tiles. If a crime were to occur on a floor with these floor tiles under all the evidence, determining the location of all the evidence would be extremely easy. If the crime scene currently being worked is not conveniently located on such a floor, would it not be nice if we could superimpose a uniform checkerboard grid system, like 1′ × 1′ squares, over the entire crime scene? If this can be done, extrapolating the measurements of all the evidence within the crime scene would be vastly simplified. This is what photogrammetry is all about. "Photographs can be used to make up for a lack of suitable measurements, to supplement inadequate measurements, and, in some cases, to substitute for measurements" (Baker and Fricke, 1986, pp. 30–33).

Here are just a few circumstances when the proper use of photogrammetry could be used as a backup to traditional measurements or even as a substitute for measurements at a crime or accident scene. You may be able to think of others:

- Evidence at the scene is so numerous or so intricate that locating all the items of evidence within the scene would require an inordinate number of measurements (Baker and Fricke, 1986, pp. 30–33). Consider a complex accident scene, with skid and scuff marks, scattered debris, liquid runoff, gouge marks, vehicle damage, sight-line questions, etc.
- The on-scene investigator or the evidence technician has no way of knowing what may later be important to the reconstructionist subsequently called in to analyze the scene (Whitnall and Millen-Playter, 1988). Without advanced training in accident reconstruction, an evidence technician may not know just what is important for the reconstruction of the accident.
- With unfavorable weather conditions, traditional methods of measuring items of evidence may not be possible. Evidence may be blown away by high winds, washed away by heavy rains, or covered by a snowstorm. Frozen surfaces may make walking around the scene difficult or impossible (Baker, 1983, p. 2). Yes, it would be preferable to pull out the tape measure and do it all the old-fashioned way, but sometimes the evidence just might not wait for this process.
- The investigator must work alone or without the normally available equipment. Are we not always blessed with multiple assistants to help with every request, and we certainly have all the equipment available on the TV show *CSI*? TV is entertainment; real-world crime and accident scenes are often quite a challenge (Baker and Fricke, 1986, pp. 30–33).
- Every outdoor crime scene and every accident scene can easily be roped off, correct? At the peak of rush hour, diverting traffic from the main road, for as long as the investigation takes, is always easily possible, correct? One memory relates to this. A police officer's cruiser was T-boned by a car that had run a stop sign. The collision forced the cruiser across double yellow lines, where it then also struck an oncoming car. The officer was badly injured and later retired because of his injuries. Wanting to do our best for a brother officer, we wanted to do the best job we could with the accident investigation and the documentation of the accident scene.

One problem: it was rush hour on our most heavily traveled road. Our Chief of Police drove by and told us we had 45 min to clear the scene. Traditional measuring methods went out the window.

- For whatever the reasons, the investigator must hurry, or does not have the time to take traditional measurements. We have all been working an important crime scene, and have just begun, when an even more urgent call comes out, and no one else is available. Street cops become experts at shortcuts. Sometimes, the "normal" way just is not a choice.
- There are many "minor" crime and accident scenes that do not seem to call for the full battery of what is routinely done at "major" scenes. We routinely apply the amount of effort at scenes as they deserve. Time management: every scene is not a triple homicide, and manpower and effort are usually appropriate for the occasion. Unfortunately, some of these "minor" scenes later turn out to be "major" scenes. Unexpectedly, several days or weeks later, someone dies, and what was originally just an assault and battery is now a homicide. Whenever necessary, you can go back and take the photographs and measurements and notes that would have been done, had everyone known it was a homicide the night of the original call, correct? With a knowledge of photogrammetry, sometimes you *can* go back, and with the original photographs, you can get more information out of the photographs.
- "Insurance shots": Knowing the possibilities of photogrammetry, it is advisable to take one or two more photographs "just in case." Then, if it becomes necessary later, these photographs can be used to gather more information than you intended to collect initially. We are always being told we cannot go back again and redo many of the things we had wished we had done. With photogrammetry techniques available to us, this attitude may have to be reevaluated. Sometimes, we *can* go back again; we *can* use the original photographs to glean more information and data out of the photographs we already have in our possession.

This author is aware that some very sophisticated measurement systems are available to some departments. Total Station and Leica Geosystems 3D ScanStations are two of these crime scene and accident scene measurement systems. Laser sighting devices are married to computer crime scene diagramming software, and 3D computer-generated diagrams are the result. These are fantastic tools. However, many agencies may not have access to these kinds of equipment. Between hand-drawn crime scene diagrams and the Total Stations and Leica ScanStations systems available to some agencies, photogrammetry can fill a very big void.

PERSPECTIVE GRID PHOTOGRAMMETRY

You have already been introduced to the concept of a scale being an essential item of equipment when taking close-up photographs. A **Perspective Grid** can now be considered the scale for an overall photograph.

In overall photographs, much of the entire scene can often be seen in one photograph. Rather than just give the viewer an impression of the layout of the entire scene, another photograph can be taken from the same position, but this time a perspective grid can be included in the scene. Then, with the grid in the scene, all items of evidence in the photograph with the grid can ultimately be linked to the grid. How accurately linked to the grid? As accurately as if each item of evidence had been measured traditionally with a tape measure.

There is not much required of a perspective grid; minimally, it is just a rectangle of known dimensions. However, it is often a 1′ × 1′ floor tile. Better yet, put four 1′ × 1′ floor tiles together, and you have a 2′ × 2′ perspective grid. However, any known rectangle can be used, and this can include your clipboard.

Fig. 8.1 shows this author's set of four well-loved floor tiles used as a perspective grid. This author's first perspective grid was made of cardboard. It was quickly discovered that cardboard warps in the rain and blows away in the wind. Vinyl floor tiles lie flat, laugh at the rain, and remain in place during windy conditions. When you are selecting floor tiles, tiles that are nonglossy are preferred because having glare on any floor tile will make it harder to see the lines on the grid. With larger scenes, all four 1′ × 1′ tiles are used together. With smaller scenes, like evidence on a bed, a single 1′× 1′ floor tile can be used. Fig. 8.2 shows such a 1′ × 1′ grid. It was a thank-you gift from several officers grateful to have learned how to use photogrammetry.

RULE OF THUMB 8.1

When the perspective grid is photographed at the crime scene, it is composed so that it is low and centered in a photograph, with evidence beyond it and to the left and right of the grid.

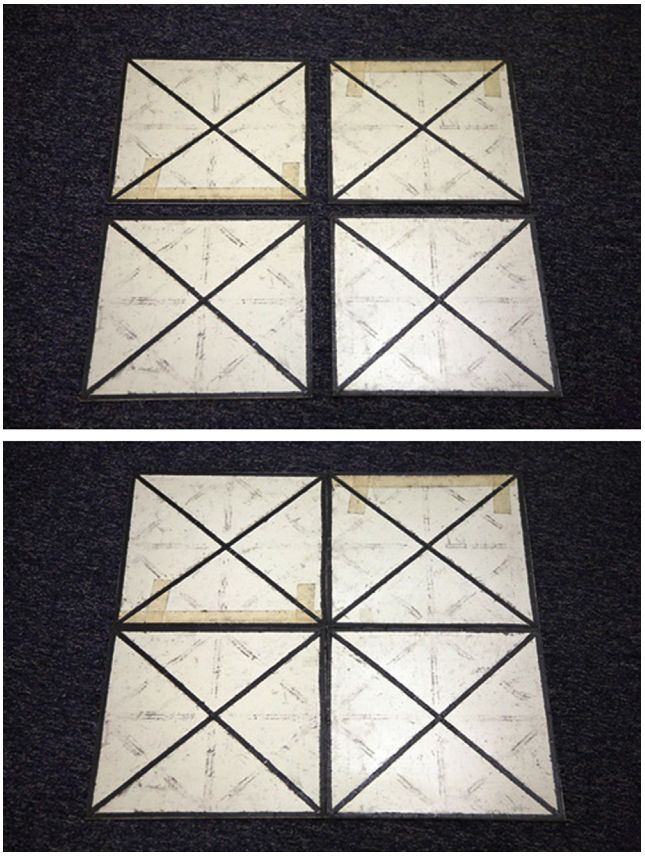


FIGURE 8.1
Four separate 1′ × 1′ floor tiles.

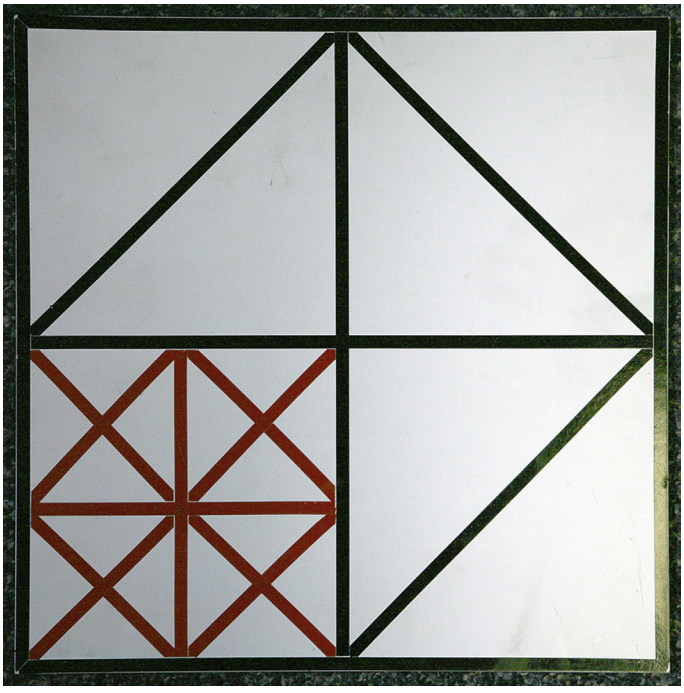


FIGURE 8.2
1′ × 1′ perspective grid.
Courtesy of Metropolitan Washington Airports Authority Police Department.

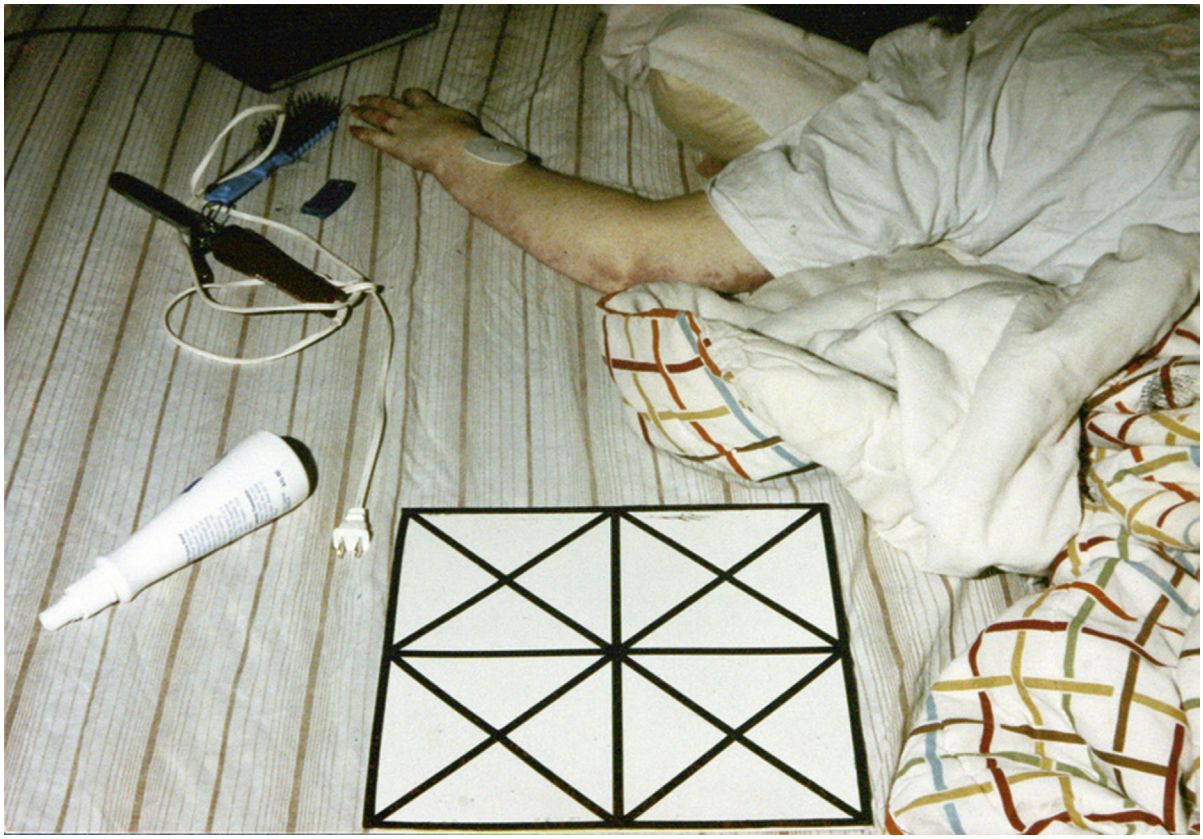


FIGURE 8.3
1′ × 1′ perspective grid in a homicide scene photograph.
Courtesy of the Arlington County Police Department, Arlington, VA.

Where the grid is placed within the scene is up to you. Position it so that as many items of evidence as possible can be composed in a single photograph with the grid. If all items of evidence cannot be composed in one photograph with the grid because furniture or other obstacles block the view of some of the evidence when viewed from one position, it will be possible to reposition the grid so that the remaining items of evidence can be linked to the grid in a second or third photograph. When you are composing such a photograph, try to arrange the grid so that its bottom edge runs parallel to the bottom of the composed photograph and the grid is close to the middle of the bottom of the image.

Fig. 8.3 shows a 1′ × 1′ perspective grid on a bed. It is, as suggested, low and centered in the composition. This image was taken to relate all the items on the bed to the body of a homicide victim. This was originally taken as a "backup" photograph. All the evidence was going to be measured traditionally. As the items of evidence were photographed, measured, and removed from the bed, a supervisor came into the room and asked a question. The crime scene investigator, this author, stopped to answer the question. Returning to the evidence collection, this author picked up the next item of evidence. It was then realized that this particular item of evidence had not been measured yet. After an initial panic attack swept over the crime scene investigator, a sigh of relief was uttered when it was remembered that the photo in Fig. 8.3 had just previously been taken. If this author had not been convinced of the value of photogrammetry before then, he has been ever since.

Rather than explain the concepts of perspective grid photogrammetry as abstract theory, this chapter walks you through a real practical exercise.

Fig. 8.4 shows an image with a perspective grid in it. It is also included on the Companion Website that accompanies this text (Available at, http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646). Feel free to print it out onto a full sheet of paper and work through the exercise as you follow the process. This image has three items of "evidence" in view: a set of keys, a pair of sunglasses, and a purse. Each will be linked to the grid.

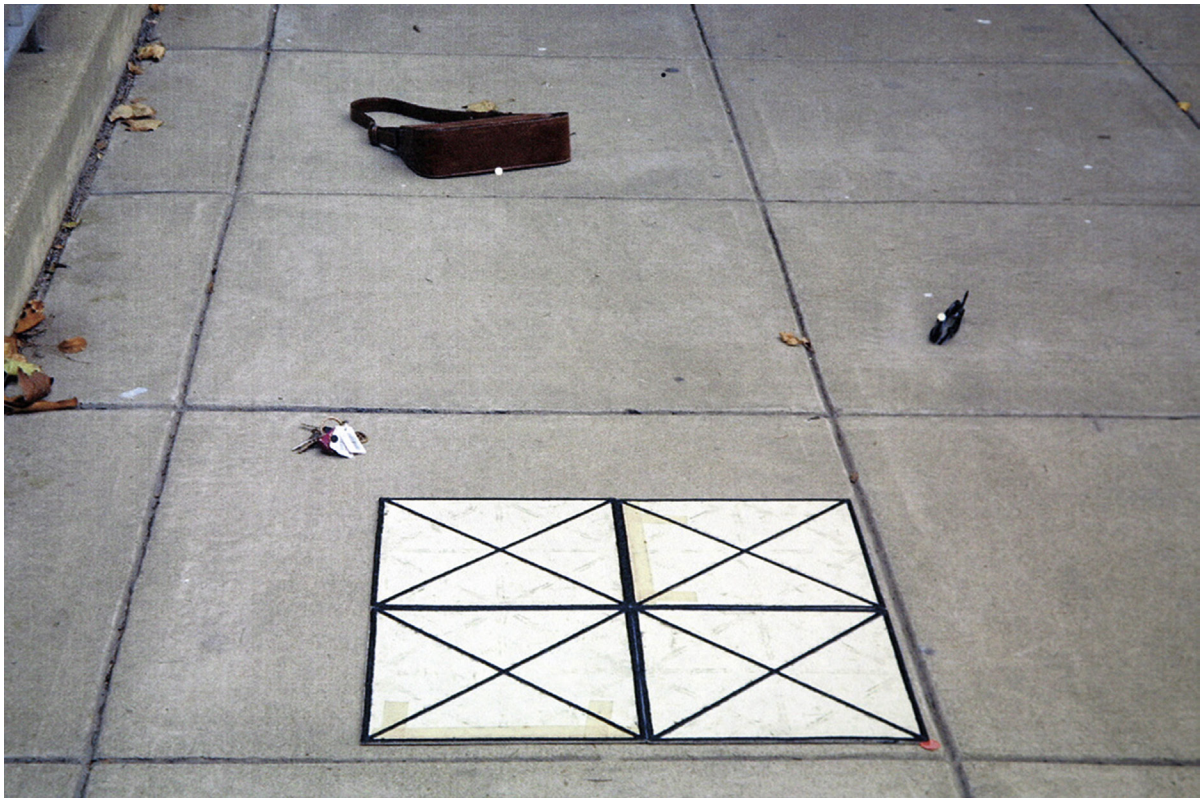


FIGURE 8.4
Practical exercise image.

Mark the Evidence

When evidence is normally measured at crime scenes, the center of mass is usually measured. Working from a perspective view makes this difficult or impossible at times. When the evidence is viewed in a photograph, the center of mass can often not be determined. If the center of mass cannot easily be determined, rather than guess where it is and risk haggling over this issue with a defense attorney, you must develop a new method of measuring the evidence. From the perspective point of view, it is easy to see the center of an edge of the evidence closest to the viewer of the photograph. Select the center of one edge of the evidence where it comes into contact with the surface it is on, and place a dot there. That dot will now represent the evidence. In Fig. 8.4, the purse has been marked by this method. When later locating the purse in the scale crime scene diagram, just remember the point in the diagram is not the center of mass, which you are used to measuring; it is one side of the evidence.

If the center of mass can still be determined from a perspective viewpoint, place a dot at this location. This dot will now represent the evidence. In this example, both the keys and sunglasses can be marked this way.

Grid Extension

You now begin the process of taking the perspective grid and extending it over the evidence within the scene. You will put a checkerboard of known dimensions over the scene to make it easy to determine the location of the evidence. To make this easier for the novice to photogrammetry, a sheet of paper was placed over the original photo in Fig. 8.4, with cutouts in the area of the perspective grid and the dots representing each item of evidence. This step is not necessary in real cases, but when the perspective grid technique is taught for the first time, it simplifies things quite a bit. Many lines will have to be drawn out over the crime scene image, and it will be easier to make sense of the lines if they are on a clean white background. Fig. 8.5 shows the crime scene photograph covered with paper that has cutouts for the grid and evidence.

Because many lines will be drawn to the left, right, and above the original photograph, additional paper is taped to the original image. Fig. 8.6 shows additional paper taped to the original photograph.

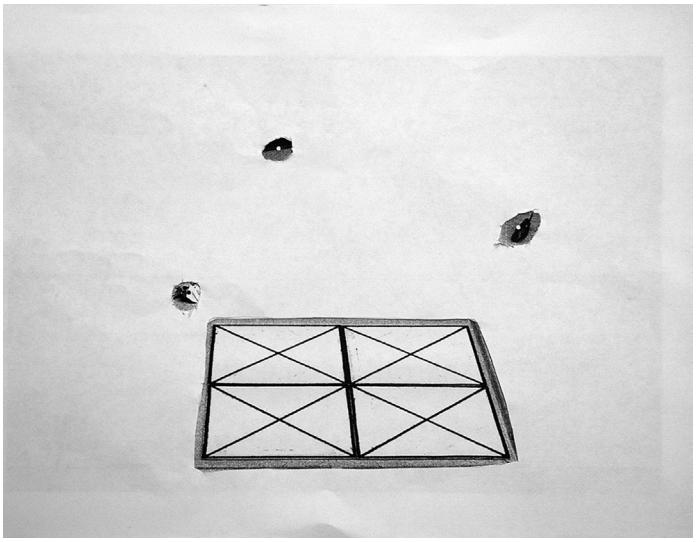


FIGURE 8.5
Covered with paper with cutouts for the grid and evidence.

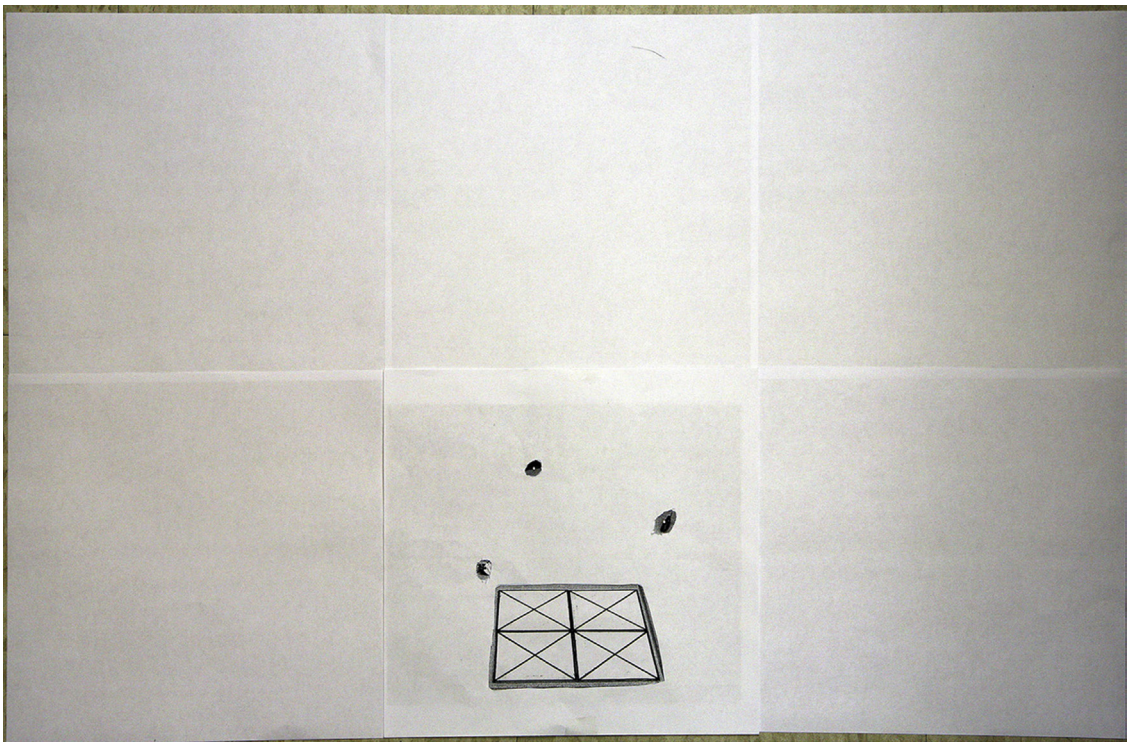


FIGURE 8.6
Additional paper taped to the original photograph.

Next, extend the four sides of the original 2′ × 2′ grid. It is important to use care when doing this because any inaccuracies in extending the grid sides will result in progressive inaccuracies in the eventual measurements that are determined. The black tape on the edges of the grid is there to help you locate the outside edges of the grid. Do not extend lines from the inside edge of the black tape or the middle of the black tape. Make sure to extend the edge of the grid or the outside edge of the black tape. Where the left and right sides of the grid meet can be labeled the Y-intersecting point because this will eventually be the top of the Y-line of an (x,y) coordinate system. The Y-intersecting point has also been called the "vanishing point" by some authors writing about photogrammetry. The lines extending the top and bottom of the original grid can now be referred to as horizontal parallel lines. The lines extending the left and right sides of the original grid can now be referred to as vertical parallel lines, although,

in perspective, they do not appear parallel. The line that is the extension of the base of the original grid can now be considered the X-line of the (x,y) coordinate system. Fig. 8.7 shows the four sides of the grid extended to the left, right, and above the original image.

Measure the distance of the base of the original 2′ × 2′. Be as accurate as possible. If your scale has them, measure the base of the original grid to an accuracy of 1/32nd of an inch. After determining this distance, from the lower left and right corners of the grid, measure out this same distance to the left and right of the grid along the baseline. Place a hash mark on the baseline at these two locations. Measure one more increment of the grid's base length to the left and right of the first two hash marks and place two more hash marks on the baseline. You should now have four hash marks on the baseline. Including the original grid's length, there will now be five lengths on the baseline, all the length of the base of the original grid. Fig. 8.8 shows this.

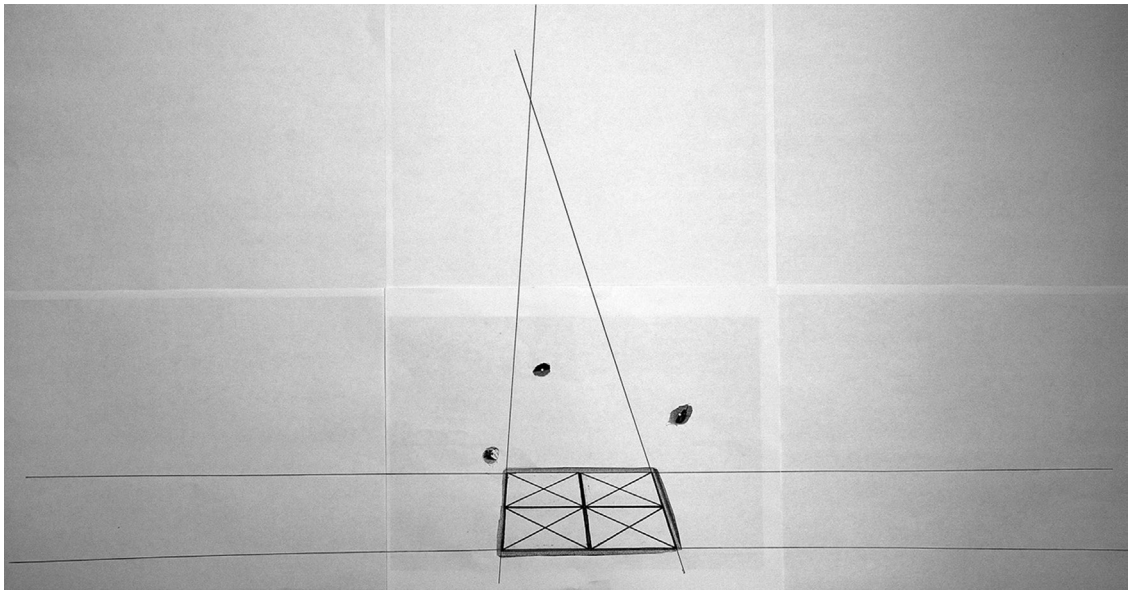


FIGURE 8.7
The four sides of the grid extended.

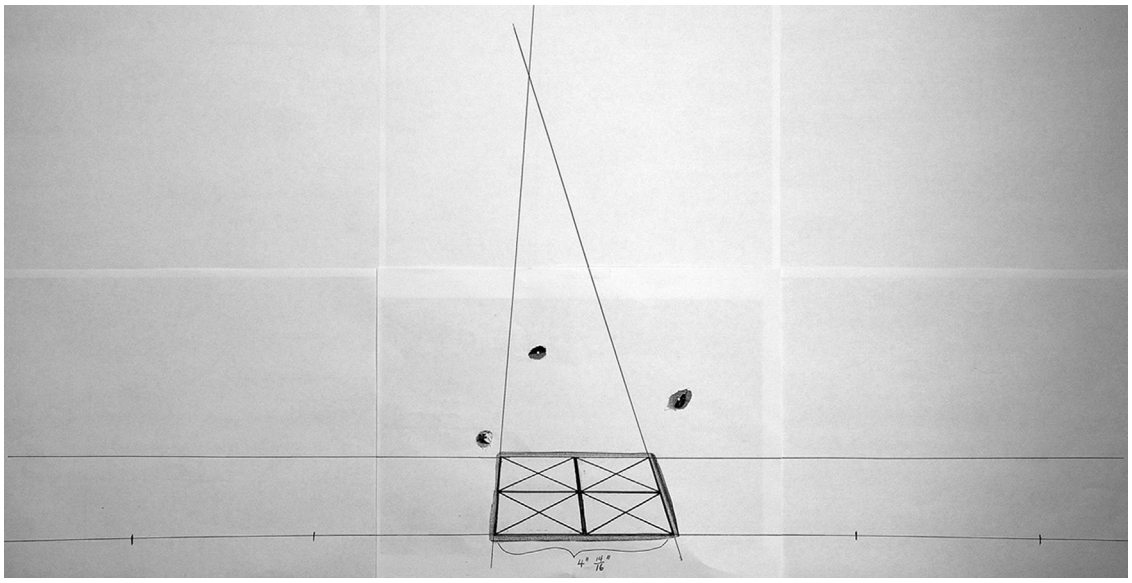


FIGURE 8.8
The grid base length duplicated four times.

Connect each of the four hash marks to the Y-intersecting point, or vanishing point, which was determined by extending the left and right sides of the original 2′ × 2′ grid. Notice there are now five 2′ × 2′ squares; the original grid and two to the left and two to the right. The original grid must be extended until all the evidence falls within a 2′ × 2′. If any item of evidence still lies outside the "teepee" drawn so far, it will be necessary to extend the original grid's base length to the left or right on the baseline, make a new hash mark, and connect that hash mark to the Y-intersecting point. Fig. 8.9 shows the "teepee" formed by connecting the four hash marks with the Y-intersecting point.

Cross the corners of the original 2′ × 2′ grid and extend these diagonal lines until they reach the sides of the "teepee." This will allow the formation of 2′ × 2′ squares above the original row of five 2′ × 2′ squares. Fig. 8.10 shows the original grid's corners crossed and extended.

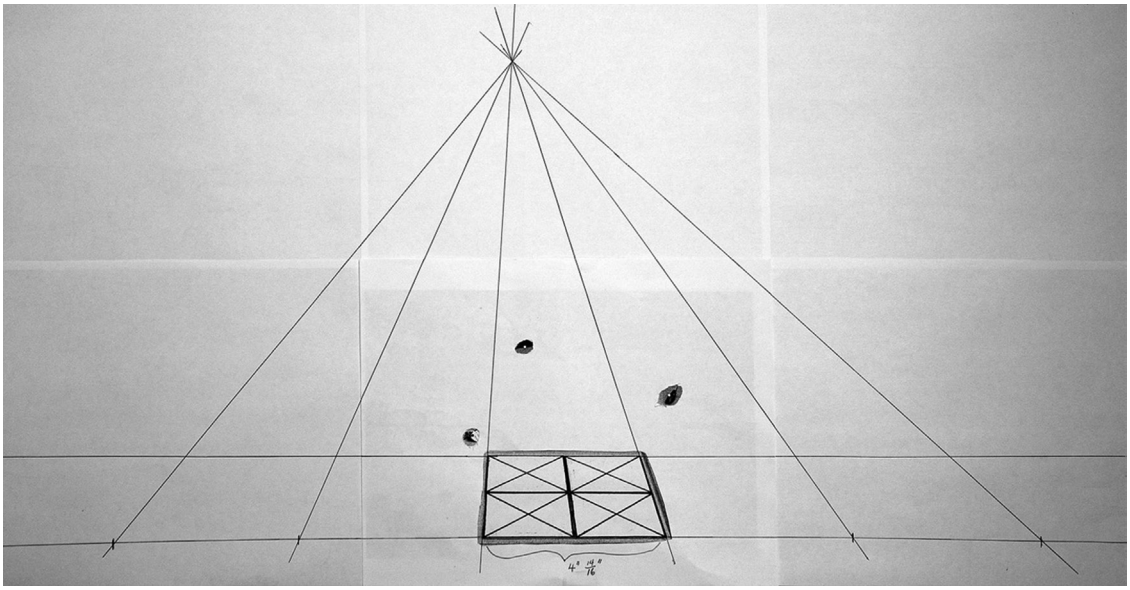


FIGURE 8.9
Hash marks connected to the Y point.

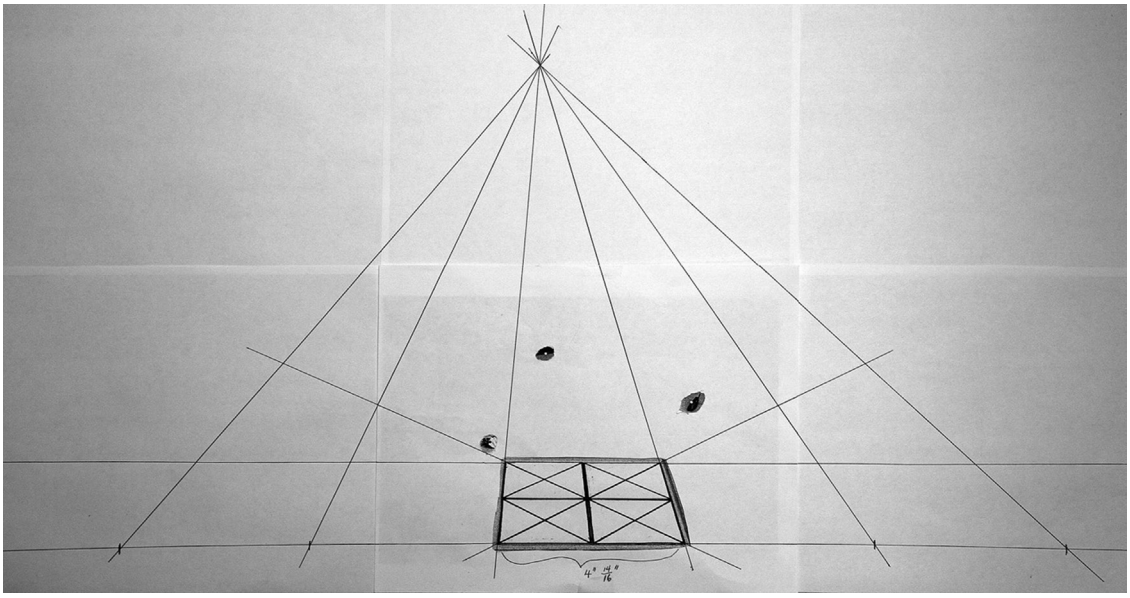


FIGURE 8.10
Original grid corners crossed and extended.

Note where these diagonal lines intersect the vertical parallel lines coming from the **first** two hash marks on the baseline from the original grid. These two intersecting points can now be connected with a new horizontal parallel line. When this is done, note there are now 10 2′ × 2′ squares. If all the evidence is not enclosed inside a 2′ × 2′ square, more horizontal parallel lines will have to be added. Fig. 8.11 shows this new horizontal parallel line added.

Note where the diagonals intersect the vertical parallel lines coming from the **second** two hash marks on the baseline. These two intersecting points can now be connected with a new horizontal parallel line. When this is done, note there are now 15 2′ × 2′ squares. If all the evidence is not enclosed inside a 2′ × 2′ square, more horizontal parallel lines will have to be added. Fig. 8.12 shows this new horizontal parallel line added.

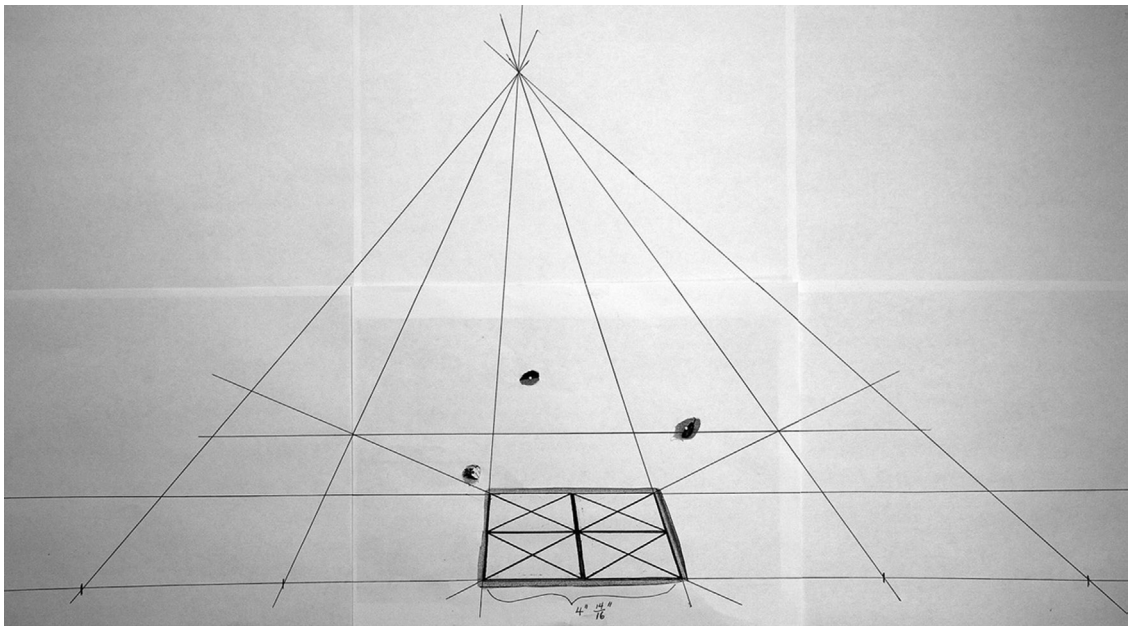


FIGURE 8.11
Third horizontal parallel line added.

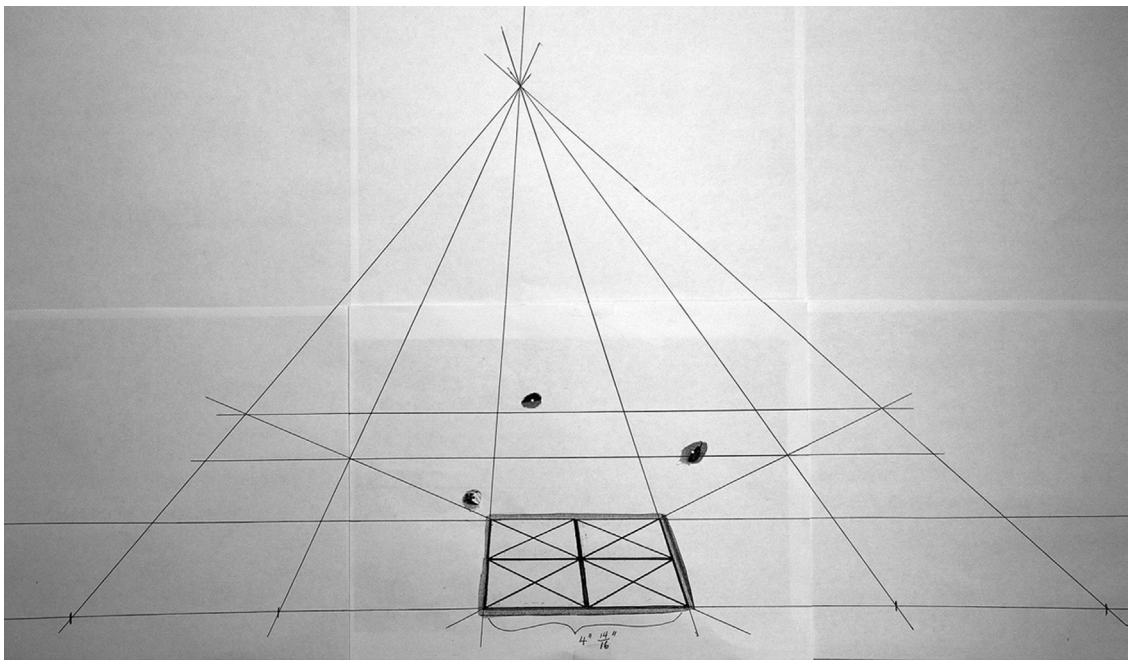


FIGURE 8.12
Fourth horizontal parallel line added.

Two of the items of evidence are now enclosed in a 2′ × 2′ square, but the grid has to be extended to the left, right, and above the original grid until every item of evidence is within a 2′ × 2′ square. To extend the grid system higher, note the 2′ × 2′ square above the original grid, and cross its corners, extending the lines out to the edge of the "teepee." An accuracy checkpoint is now available. When aligning the opposite corners of the 2′ × 2′ square above the original grid, if you were to extend these diagonal lines downward (you do not have to actually draw the lines downward), you should note that the diagonal lines would intersect the first two hash marks on the baseline. If they would, you can be assured your work up to this point has been accurate. If extending the diagonal line downward would not intersect these first hash marks, this is a sign something has not been done properly, and any measurements derived will not be accurate. If the diagonal line extended downward is only about 1/32nd or 1/16th of an inch off meeting the hash marks, you may continue, but expect your measurements to be up to 1″ to 2″ or more off. If the inaccuracy is farther off, it would be best to begin the grid extension from the beginning. Fig. 8.13 shows the corners of the grid above the original grid with its corners crossed and extended to the edges of the "teepee." Note that one diagonal has been extended down to the baseline, where it intersects one of the hash marks. That it intersects the hash mark is a confidence builder.

Where the diagonal lines intersect the sides of the "teepee," you can connect these intersecting points with a fifth horizontal parallel line (see Fig. 8.14).

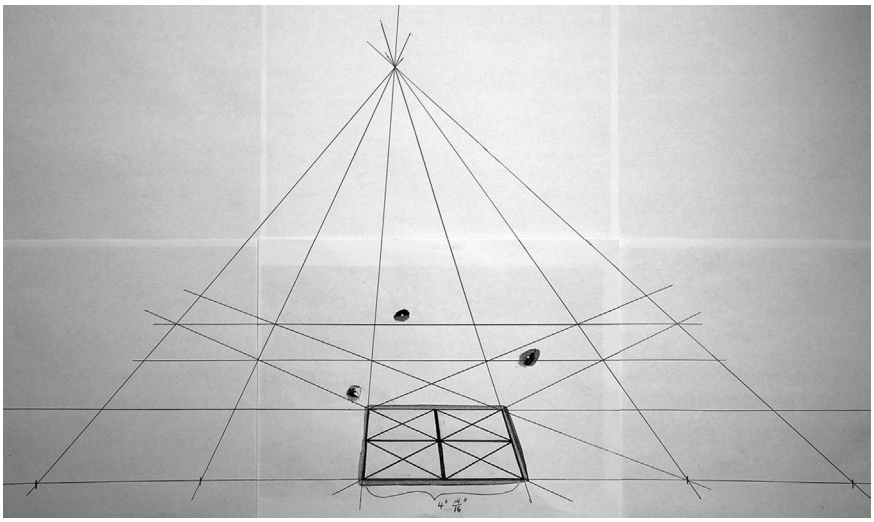


FIGURE 8.13
Second grid's corners crossed.

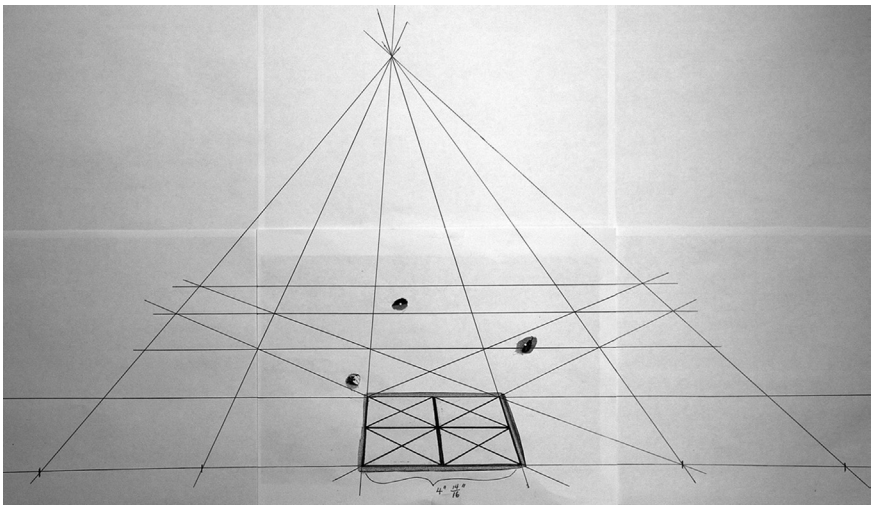


FIGURE 8.14
Fifth horizontal parallel line added.

If all the items of evidence are not now located within a 2′ × 2′ square, continue crossing the corners of 2′ × 2′ square above the original grid, and use these new diagonals to draw more horizontal parallel lines.

Once all the evidence is located within a 2′ × 2′ square, it is now necessary to label all the lines drawn. Indicate horizontal parallel lines in increments of 2′.

Now is a good time to draw a line straight down from the Y-intersecting point/vanishing point into the **middle** of the original grid. The baseline of the original grid is 2′ long. The middle of this line can be marked the (0,0) point of the (x,y) coordinate system. The line coming down from the Y-intersecting point to the (0,0) point will be called the Y-line. Where the Y-line intersects the X-line is the (0,0) point of an (x,y) grid system. From the (0,0) point to both corners of the original grid are 1′ distances. Where the first two hash marks are located are 3′ marks, and where the second two hash marks are located are 5′ marks, as in Fig. 8.15.

Grid Reduction

Now that every item of evidence has been enclosed in a 2′ × 2′ square, it is necessary to reduce the size of each grid to more accurately determine the exact location of the dot representing each item of evidence. Cross the corners of every 2′ × 2′ square that has an item of evidence within it. These lines do not have to be extended outside the 2′ × 2′ square involved. Also, cross the corners of an adjacent 2′ × 2′. For every 2′ × 2′ square that has evidence within it, pick another 2′ × 2′ square, either to the left or right of it, and cross its corners also. Fig. 8.16 shows all these 2′ × 2′ squares crossed.

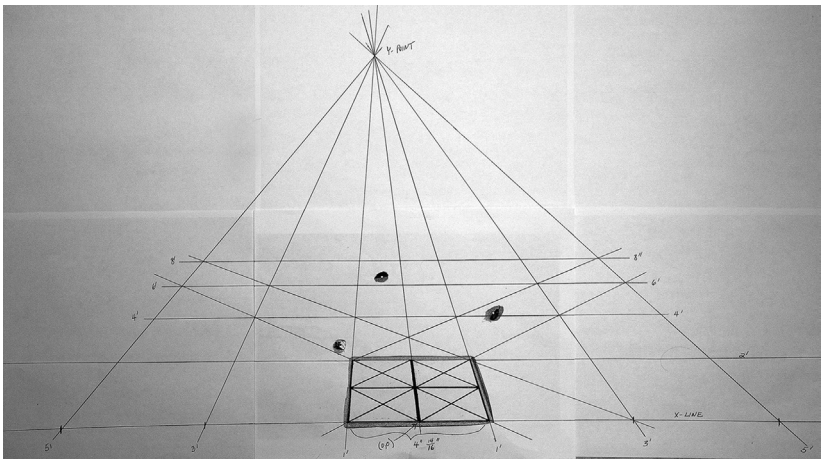


FIGURE 8.15
All lines marked.

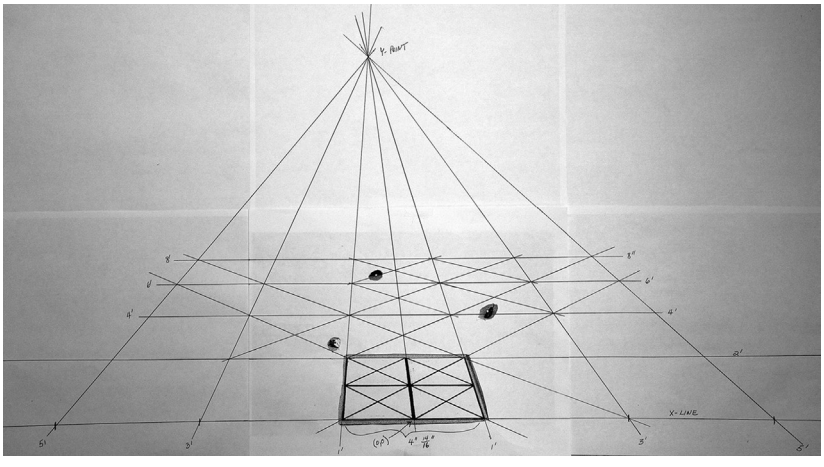


FIGURE 8.16
Cross the corners of every grid with evidence in it and an adjacent grid.

Each 2′ × 2′ square with evidence in it can now be bisected, both vertically and horizontally. To bisect a 2′ × 2′ square vertically, align the X formed by crossing the corners within the 2′ × 2′ with the Y-intersecting point. It is not necessary to draw a line from the Y-intersecting point to the 2′ × 2′ with evidence in it. Align the ruler with the Y-intersecting point and the X showing the center of the 2′ × 2′ with evidence in it. Only draw a line that bisects **the 2′ × 2′ square** with the evidence in it; it is not necessary to draw the line all the way down from the Y-intersecting point. Try to avoid drawing unnecessary lines. This will make it more difficult to determine exactly where the evidence is in relation to the (0,0) point.

To bisect a 2′ × 2′ square horizontally, align the X of the 2′ × 2′ square with the evidence in it with the X formed when crossing the corners of an adjacent 2′ × 2′ square. Just bisect **the 2′ × 2′ square** with the evidence in it. Fig. 8.17 shows the grid with the keys in it bisected both vertically and horizontally. The grids with the sunglasses and purse are also bisected both vertically and horizontally in like manner.

From now on, when new vertical and horizontal lines are drawn, immediately label them as to their distance from the X-line and Y-line. If each new line is immediately labeled, it will be easier to later determine the location of the evidence. The 2′ × 2′ grid with the keys in it has now been bisected into four 1′ × 1′ squares. The dots representing the evidence are all now located within a 1′ × 1′ square.

To reduce the size of each 1′ × 1′ grid any evidence is within, repeat the preceding directions. Cross the corners of each 1′ × 1′ grid with evidence with it, and an adjacent 1′ × 1′ grid. Fig. 8.18 shows the 1′ × 1′ grid with the keys in it after its corners have been crossed, and an adjacent 1′ × 1′ grid also has had its corners crossed.

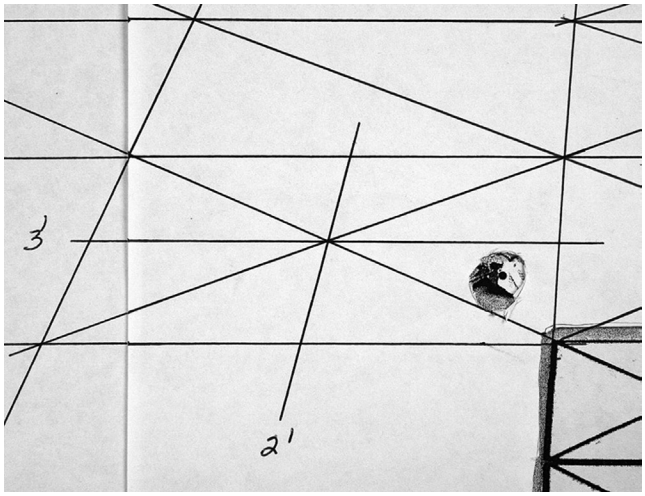


FIGURE 8.17
2′ × 2′ with keys bisected vertically and horizontally.

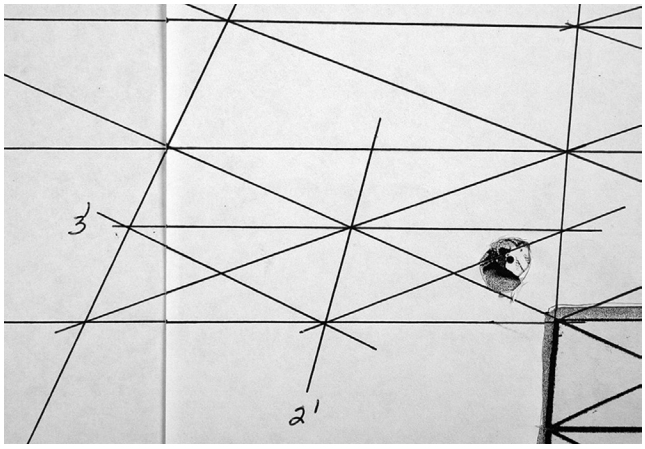


FIGURE 8.18
1′ × 1′ with keys with corners crossed.

Each 1′ × 1′ grid with evidence in it can now be bisected both vertically and horizontally. To bisect a 1′ × 1′ grid vertically, align the X formed by the corner crossing within the 1′ × 1′ grid with the Y-intersecting point. Only draw a line that bisects the 1′ × 1′ grid with the evidence in it; it is not necessary to draw the line all the way down from the Y-intersecting point. To bisect a 1′ × 1′ grid horizontally, align the X of the 1′ × 1′ grid with the evidence in it with the X formed when crossing the corners of an adjacent 1′ × 1′ grid. Just bisect the 1′ × 1′ grid with the evidence in it. Fig. 8.19 has the 1′ × 1′ grid with the keys in it bisected into four 6″ × 6″ squares. When you draw new vertical and horizontal lines, immediately label them as to their distance from the X-line and Y-line. If each new line is immediately labeled, it will be easier to later determine the location of the evidence.

This entire process is usually repeated one more time. Cross the corners of each 6″ × 6″ square with evidence within it and an adjacent 6″ × 6″ square. This is shown in Fig. 8.20.

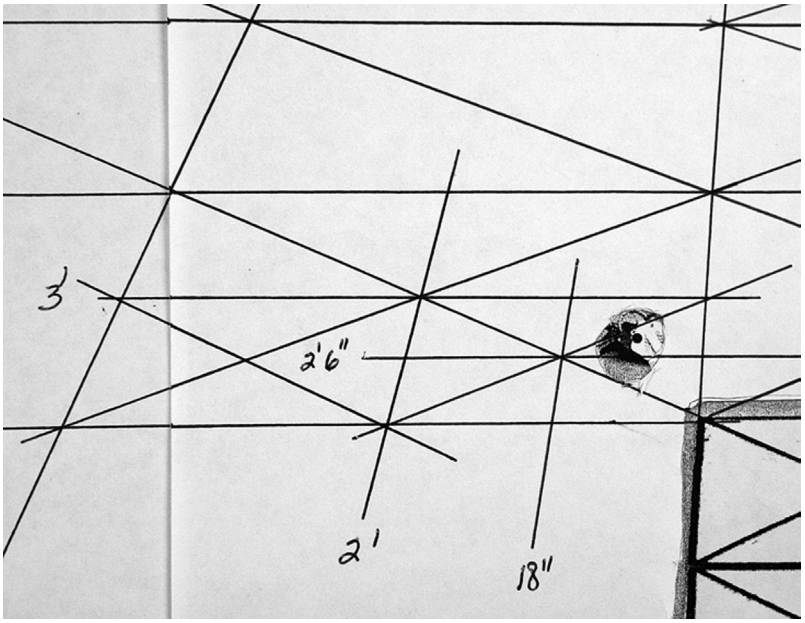


FIGURE 8.19
1′ × 1′ bisected into four 6″ × 6″ squares.

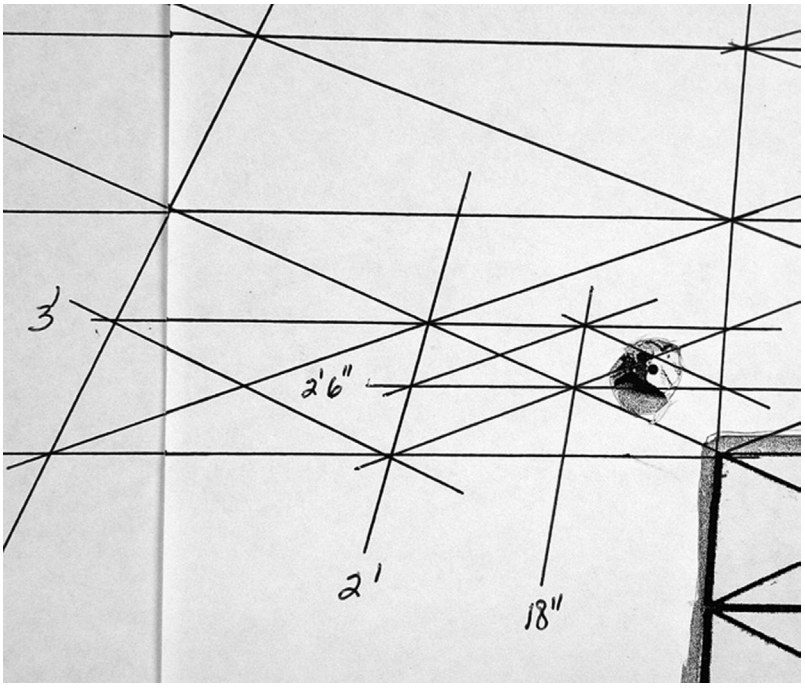


FIGURE 8.20
6″ × 6″ with corners crossed.

Each 6″ × 6″ square with evidence in it can now be bisected, both vertically and horizontally. To bisect a 6″ × 6″ square vertically, align the X formed by the corner crossing within the 6″ × 6″ square with the Y-intersecting point. Only draw a line that bisects the 6″ × 6″ square with the evidence in it; it is not necessary to draw the line all the way down from the Y-intersecting point. To bisect a 6″ × 6″ square horizontally, align the X of the 6″ × 6″ square with the evidence in it with the X formed when crossing the corners of an adjacent 6″ × 6″ square. Just bisect the 6″ × 6″ square with the evidence in it. Fig. 8.21 shows the 6″ × 6″ square bisected into four 3″ × 3″ squares.

Once all the dots representing the evidence are located within 3″ × 3″ squares, no further square reductions are necessary. On one vertical 3″ line, draw two hash marks, each approximately 1″ from the other. On one horizontal 3″ line, draw two hash marks, each approximately 1″ from the other. There is no need to precisely measure these hash marks. Careful approximations are all that are required. It should now be easy to approximate the location of each item of evidence (*a dot*) as to its relation to both the X-line and Y-line accurate to the closest inch. Fig. 8.22 shows the 3″ × 3″ square with the dot in it divided into thirds both vertically and horizontally.

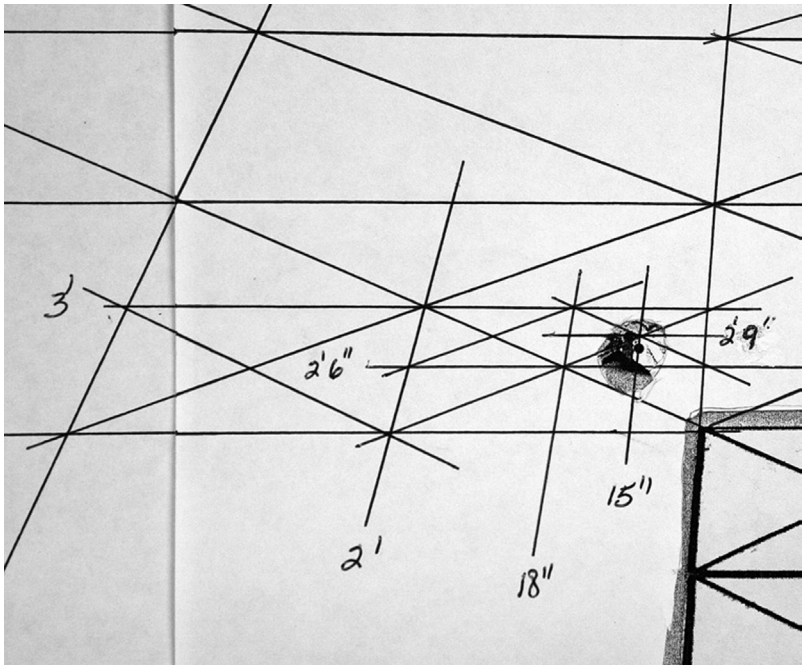


FIGURE 8.21
6″ × 6″ bisected into four 3″ × 3″ squares.

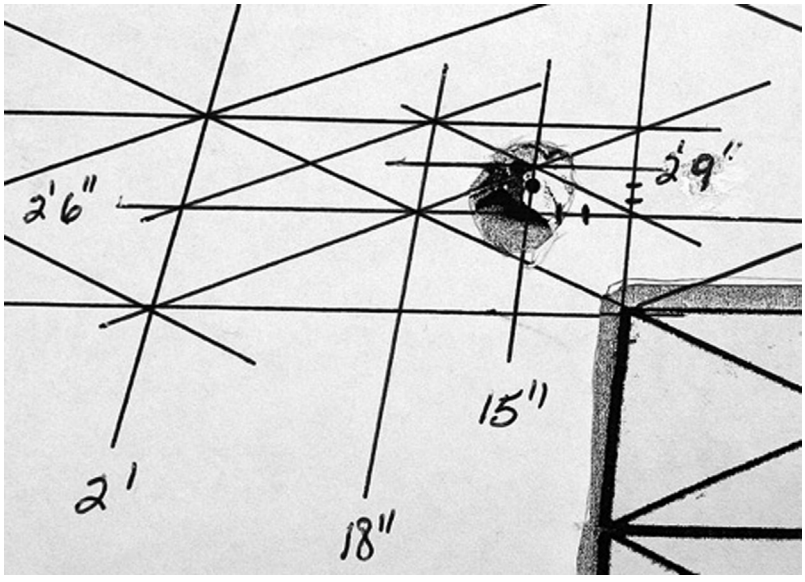


FIGURE 8.22
3″ × 3″ with sides divided into thirds.

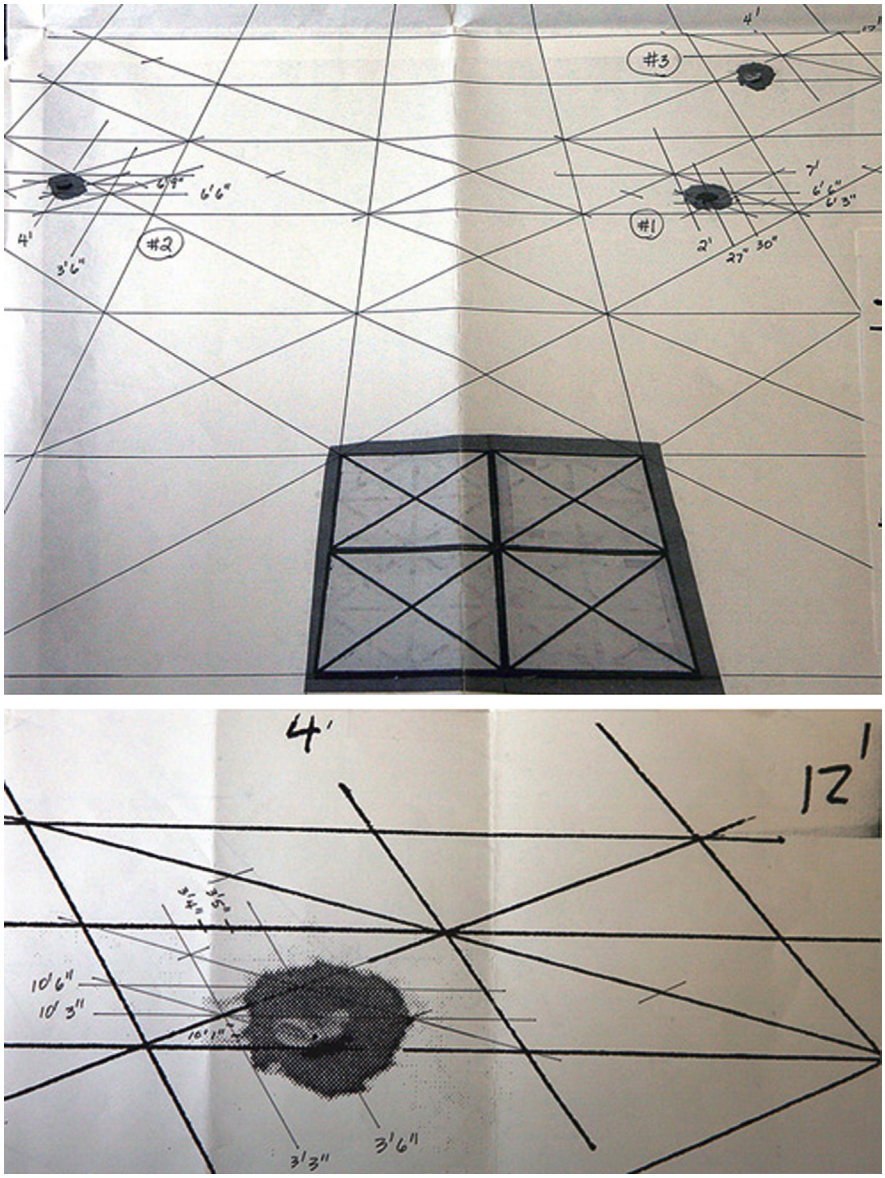


FIGURE 8.23
Small original 2′ × 2′ enlarged.

The dot representing the keys is now determined to be 2′ 8″ north on the Y-line, and 15″ west on the X-line. This can also be written as (–15″, 2′ 8″), if you are more comfortable with traditional X-Y coordinate system notation.

When this author was teaching perspective grid photogrammetry at a local police academy, it was pointed out that quartering 2′ × 2′ squares, 1′ × 1′ squares, and 6″ × 6″ squares is relatively easy when the evidence is low enough in the original photograph to end up being located in a large initial 2′ × 2′ square. When the evidence is higher in the photograph, it will eventually end up in a much smaller 2′ × 2′ square, and all the required quartering becomes difficult because all the diagonal and bisecting lines get extremely close together. This can be difficult. In these cases, then, the simple answer is to make the original small 2′ × 2′ square larger. Simply enlarge these 2′ × 2′ squares on a copy machine as large as you wish. Once these squares are larger, they will easily allow the required reductions. Fig. 8.23 shows such an example taken from a different scene.

Item 3 is a bottle of Wite-Out correction fluid, and being relatively high in the photograph, it was expected that many small lines could cause difficulties. That portion of the diagram was enlarged, and the evidence was easily determined to be 10′1″ N and 3′6″ E of the grid's (0,0) point.

If you took the trouble to work along as the directions were being given, you may want to know the correct answers for the location of the sunglasses and purse.

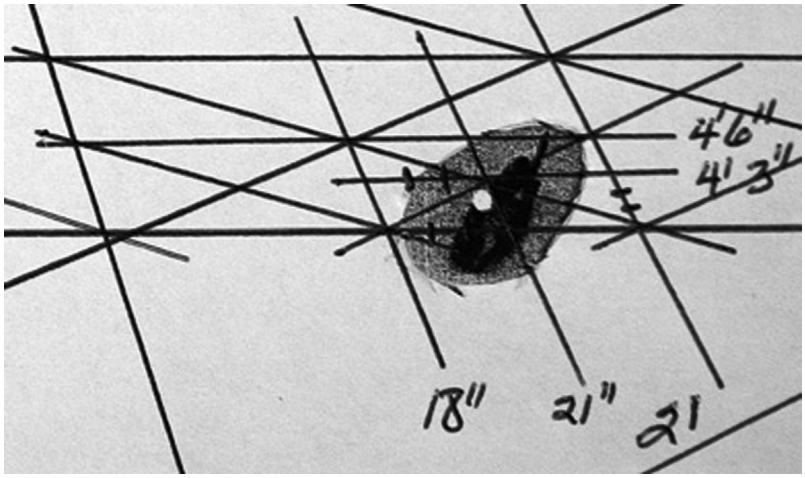


FIGURE 8.24
Sunglasses: 4′2″N, 21″E.

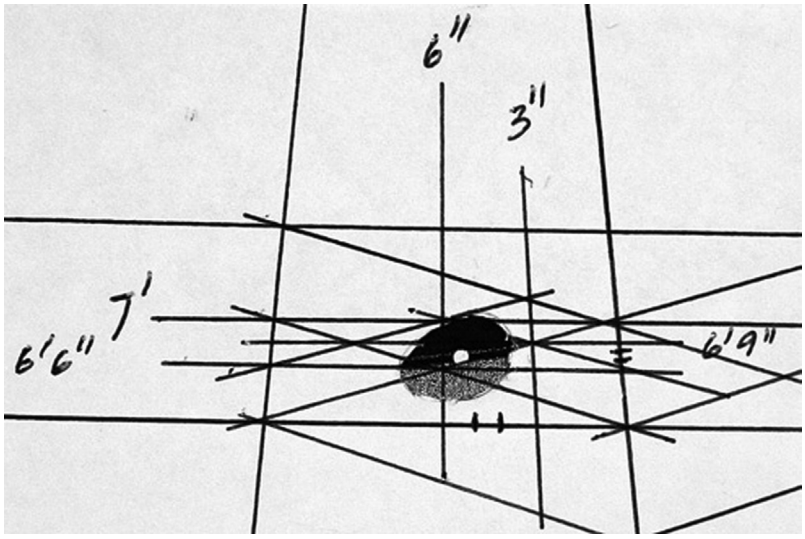


FIGURE 8.25
Purse: 6′7″N, 5.5″W.

Fig. 8.24 shows the final breakdown for the sunglasses, and Fig. 8.25 shows the breakdown for the purse.

The correct answers for the location of sunglasses are 4′ 2″ N, 21″ E. The correct answers for the location of the purse are 6′ 7″ N, 5.5″ W. It is normally recommended to round all crime scene measurements to the nearest inch. It was indicated that the purse was 5.5″ W on the X-line just to show how easy it is for the perspective grid to be that precise.

Skeptics will correctly argue that if the original grid extension over the crime scene is drawn inaccurately, the final determination of the location of an item of evidence may be inaccurately extrapolated. This is true. The initial four lines drawn, the extensions of the sides of the grid, have to be very carefully drawn. If they are extended out over the crime scene haphazardly, the determination of the location of the evidence can be inaccurate. It is recommended that the perspective grid technique be tried several times over scenes created for practice and that it not be attempted at actual crime scenes until the grid measurements are routinely accurate with practice scenes.

Locate the Evidence in the Scale Diagram

All the evidence is now associated with the (0,0) point of the original 2′ × 2′ grid. It is known how far up the Y-line the evidence is and how far along the X-line the evidence is. The perspective grid photogrammetry measurement technique is just another version of the baseline coordinate measurement technique. The question before us now is this: how is this information used to locate the evidence in a scale crime scene diagram?

If the evidence is now linked to the perspective grid, it should be obvious that the grid itself has to be linked to the crime scene somehow. How is this to be done? The grid has to be measured and fixed to the crime scene. First, the (0,0) point of the grid has to be measured. Choose the measurement technique of your choice for this. Measure the (0,0) point by the baseline coordinate method, the triangulation method, or any other measurement technique you feel comfortable with. The point is that the grid must have a known location within the crime scene.

Once the (0,0) point of the grid has been measured, one other measurement must be measured. With only the (0,0) point of the grid located in the crime scene, it would be possible for the grid to rotate around the (0,0) point, unless the spatial relationship of the grid is somehow locked in. The second measurement necessary is a point on the Y-line several feet away from the grid. It would technically be possible to measure the (0,2) point on the grid to lock its orientation into the crime scene, but it is recommended to pick some further point on the Y-line for a more accurate determination of the Y-line. When attempting to construct a line, two points are all that are required. The farther apart those two points, the more accurate the line's direction.

Fig. 8.26 shows why the line formed by connecting two dots that are close together can be less accurate than the line formed by connecting two dots farther apart. Rather than just measuring the (0,2) point, you are advised to measure some point farther down the Y-line. Its exact distance from the (0,0) point is irrelevant; the farther it is from the (0,0) point, however, the better. Place a coin on the Y-line 5′ to 10′ from the (0,0) point. Double-check if it truly is on the Y-line. If you do not trust your ability to eyeball the coin being on the Y-line when viewed from both the (0,0) point toward the coin and when viewed from the coin toward the (0,0) point, you can lay a tape measure down the Y-line from the (0,0) point to fix the Y-line and lay a coin under the tape measure. Again, it is not necessary to note the coin's distance from the (0,0) point. Its only purpose is to lock the grid's orientation in the crime scene. Measure the coin's position to lock it to the crime scene, by whatever measurement technique you wish. You now have two points measured: the grid's (0,0) point and a point on the Y-line.

These two points are placed into the crime scene diagram in scale. They are inserted into the crime scene diagram only as two lightly drawn dots because they will eventually be erased. All the evidence associated to the grid can now be located into the crime scene. Each item of evidence has a known distance out the Y-line, measured from the (0,0) dot toward the dot that is a point on the Y-line. From this Y-line, the evidence is also at known distance perpendicular to the imaginary line connecting the two dots. This distance to the left or right of the imaginary Y-line is the X-distance of each item of evidence.

So, the perspective grid measurement technique requires two measurements: the (0,0) point and a point on the Y-line. If there are only two items of evidence in the crime scene, using a perspective grid saves no time because both items of evidence will also have to be measured traditionally. However, when there are three items of evidence, or more, within view of a perspective grid laid down in the crime scene, using the perspective grid technique saves time. Just measure the (0,0) point and a point on the Y-line, and you can then pick up all the evidence.

Again, it is critical that the perspective grid measuring technique not be used at actual crime or accident scenes until the practitioner is routinely obtaining accurate measurements when the perspective grid technique is applied to mock crime scenes, when all the evidence has previously been measured by a traditional measuring technique, and all the correct answers are already known.

One restriction regarding perspective grid photogrammetry must be mentioned. This technique can be applied only to evidence on the same plane as the perspective grid. It is to be used only on flat surfaces. The reason is that evidence lower than the same plane as the grid will appear "lower" in the photograph, and items lower in the photograph will be interpreted as being closer to the grid. Evidence on a raised area will appear higher in a photograph, and evidence higher in a photograph is interpreted as being farther from the grid. Only use the perspective grid technique for scenes on flat surfaces.

This author has not used the perspective grid at very large crime scenes and would suspect its accuracy in such situations. In practice, you can feel comfortable as to the accuracy of the perspective grid technique at crime scenes no larger than about 40′. Beyond that, inaccuracies with the extension of the original grid over the crime scene may seriously affect measurement determinations. As mentioned earlier, photogrammetry is not supposed to be regarded as a replacement for all other measuring techniques. The total station types of measuring systems cannot be beat for large scenes and scenes with a rolling topography.

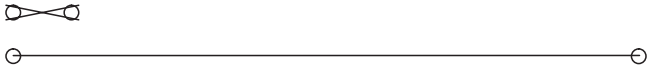


FIGURE 8.26
Two points determine a line.

PERSPECTIVE DISC PHOTOGRAMMETRY

> Should you ever have the need to testify about the measurement technique used to produce a particular crime scene diagram and happen to mention that you used the perspective grid photogrammetry technique to determine the measurements of some of the evidence, be prepared for the following. An attorney with extensive experience working with professional accident scene reconstruction companies may be very familiar with photogrammetry. Many professional accident reconstructionists use variations of photogrammetry to do their jobs. In court, an attorney may attack your credibility with some variation of this approach: "So, I understand you used perspective grid photogrammetry to determine the location of 'x' item of evidence. Sounds like a very non-traditional measurement technique. Well, I have heard of it before, and there is just one thing I'd like to know. There are many variations of photogrammetry available to anyone interested in determining measurements at accident and/or crime scenes. That being true, I'd just like to know why you chose to use a method known by all to be inferior to another photogrammetry technique? I mean, if you are going to apply photogrammetry techniques at a crime/accident scene, why use the perspective grid technique, when it is well accepted in that community that the perspective disc method is far more accurate? Why gather evidence with a poor substitute for a more highly regarded technique?"

This could go on and on. The purpose is to undermine your credibility and your expertise. What is the foundation for this attack?

True, there are variations of photogrammetry. One of those variations is called the perspective disc method.

The perspective disc method is an alternative method that can be used instead of the perspective grid technique. It is believed to result in more accurate measurement determinations because the horizon line is more precisely located during the process. The improvement in measurement accuracy is sometimes real but frequently too small to make a difference in crime scene diagrams. With the perspective disc method, three circular discs are used instead of a square or rectangular grid. Fig. 8.27 shows the same scene you are now familiar with, but this time it has three perspective discs in it. Each of these discs is 1′ in diameter. The three discs can each be 2′ in diameter. In any case, the three discs should be the same size.

With this technique, one of the three discs is arranged low and centered in the composition, just as the perspective grid was. One of the other discs is put somewhere on the right side of the composed image, and the other is placed on the left side. Their precise location is irrelevant; one just has to be to the left, and one to the right.

The next step is to draw tangential lines from the lower grid to both the other two discs. Draw lines from the right side of the lower disc past the right side of each other disc. Draw lines from the left side of the lower disc past the left side of each other disc.

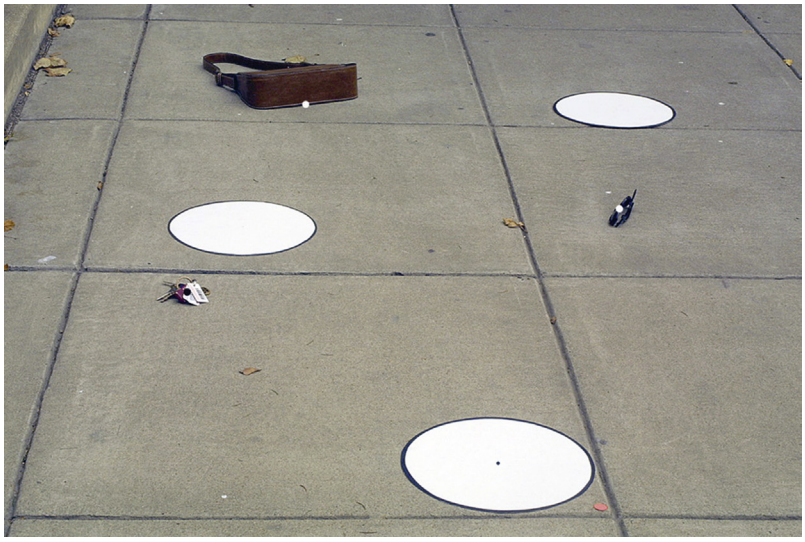


FIGURE 8.27
Perspective discs in a scene.

Fig. 8.28 is the result. Both pairs of vertical parallel lines will eventually intersect. A line can connect these two intersecting points, which is equivalent to the horizon at the scene.

This is the basis for the claim to more accuracy when using the perspective disc method. With the perspective grid technique, the horizon was determined by extending the left and right sides of the perspective grid. The Y-intersecting point was a point on the horizon line. Some claim that a more precise way to determine the horizon is to use three discs rather than one square or rectangle. That may be true, but let us continue a bit more.

From the horizon line, a perpendicular can be drawn that intersects the center of the lower disc. This is the equivalent of the Y-line. From this point on the horizon line, two more lines can be drawn that are tangential to both sides of the lower disc. Fig. 8.29 shows the result.

From this position, two lines that are perpendicular to the Y-line can be drawn that are also tangential to the top and bottom of the lower disc. The result is shown in Fig. 8.30.

Around the original disc with 1′ diameter, there is now a 1′ × 1′ square. From this point, the perspective grid technique is used to determine the location of all the evidence. The main difference between the perspective grid technique and the perspective disc technique is the accuracy by which the horizon is determined. What real difference does this make to the accuracy of any crime scene diagram resulting from both techniques? Because the perspective grid technique can result in measurements within 1″ of the known measurements at mock crime scenes set up to check the accuracy of the technique, it is suggested the perspective disc technique can result in more accurate measurements.

Is "more accurate" necessary for crime scene measurements? No. Most law enforcement agencies recommend rounding off crime scene measurements to the nearest inch. Why? Mainly because a more accurate measurement standard, $^1/_2$″ for example, will not make a difference in the final crime scene diagram. The width of your lines drawn with pencil lead or pen ink will often "absorb" crime scene measurements of less than 1 inch.

There is another reason that measuring more precisely than whole inches is often not recommended. Trying to be more precise can often be considered absurd. Many readers may recall an article on the accuracy of crime scene measurements where a huge distance was measured and recorded as something like 199′ 11.75″. Why not just indicate the distance in question was 200′? Over that distance, is another quarter inch even relevant? Most would guess

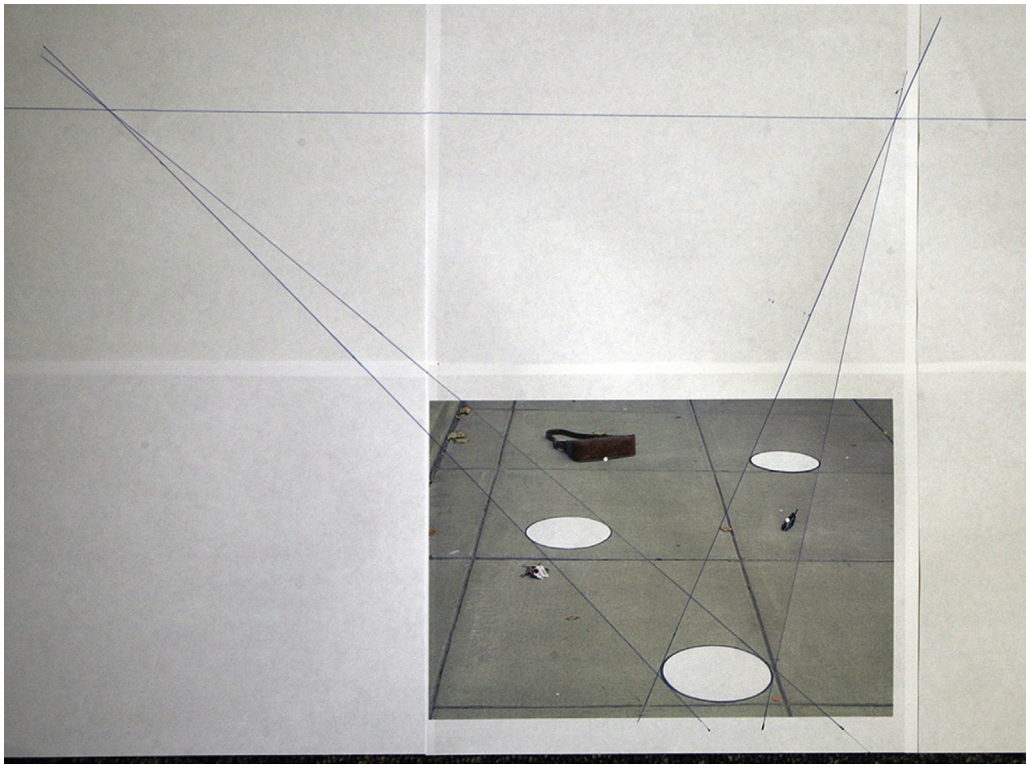


FIGURE 8.28
Tangential lines extended.

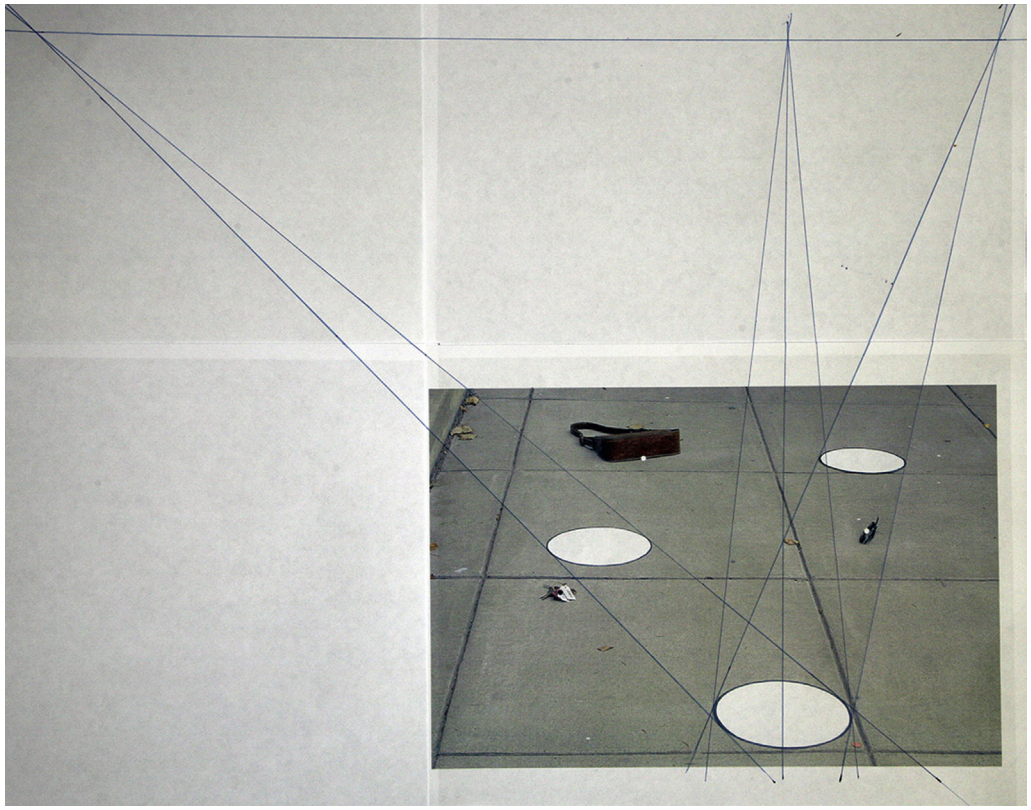


FIGURE 8.29
Lines from the horizon line to the lower disc.

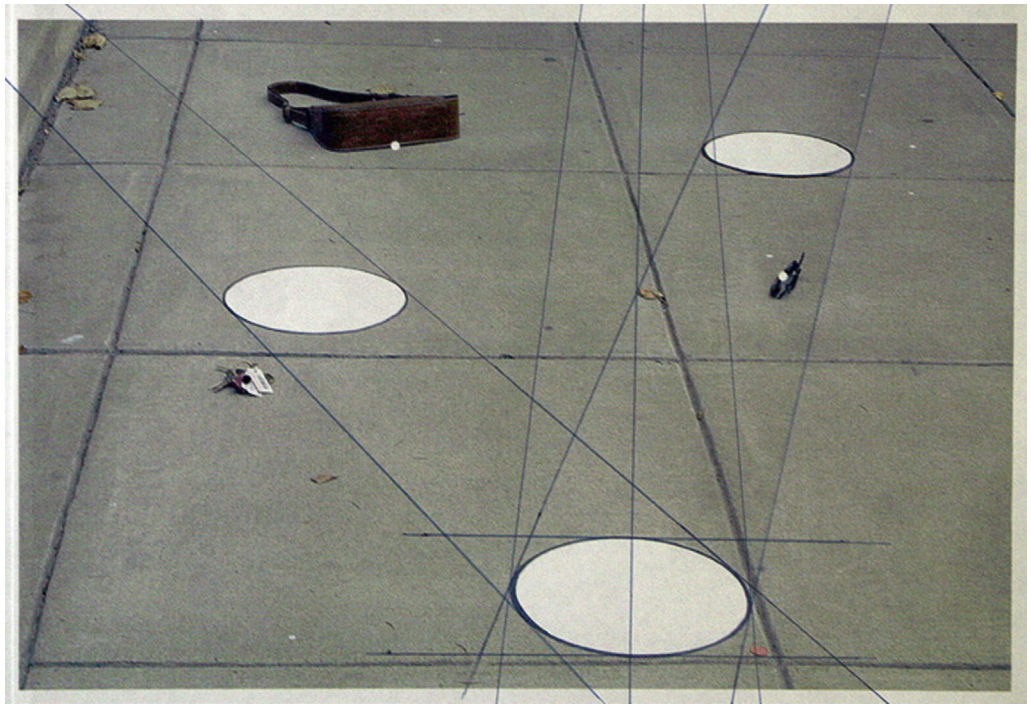


FIGURE 8.30
Horizontal tangential lines on lower disc.

if that same distance is measured five times by different people, five different distances would be recorded. For a measurement to be a "fair and accurate representation of the scene," how precise does it have to be? Most believe rounding off to the nearest inch is sufficient. Of course, many attorneys may try to argue to the jury that measuring to the nearest $^1/_2$″ is more accurate than measuring to the nearest inch. Of course, that is true. If you fall for this trap in court and state you measure to the nearest $^1/_2$″, then that same attorney will ask, with a grin, are we not aware that measuring to the nearest ¼″ would be more accurate? Of course, it is. And this ploy can continue forever because, mathematically speaking, any distance/mathematical increment can be divided in half. The real point is, at what distance increment do crime and accident scenes need to be measured to be "fair and accurate representations of the scene?" To the nearest inch!

Also, it should be mentioned that if care is exercised in extending the original four sides of the perspective grid, then measurements as accurate as can be determined by the perspective disc method *can* be obtained.

> Therefore, in the preceding scenario, when the attorney asks why you did not use the perspective disc measurement technique instead of the perspective grid measurement, because the disc method is considered to be more accurate, your answer should be something like this: "Of course, I know the perspective disc method is thought by some to be a more accurate method for determining the position of evidence. When I have applied both techniques to the same staged crime scene, the measurements produced by the perspective disc method have sometimes been slightly more accurate. The difference in accuracy, however, is so minimal that it makes no meaningful difference in the actual crime scene diagrams produced by both techniques. It sometimes produces an increase in accuracy equivalent to being more precise by ½″ or ¼″, which is not going to show up in the finished crime scene diagram. And, if done carefully, the perspective grid technique can produce measurements just as accurate as the perspective disc method."

Of course, to be able to testify to this, you do have to work several mock crime scenes with both techniques. If you find you actually prefer the disc method, by all means continue to use it. It is a very good technique.

NATURAL GRID PHOTOGRAMMETRY

Sometimes, natural features within a crime scene will make the addition of perspective grids or perspective discs unnecessary to apply photogrammetry techniques to derive the measurements of evidence within the scene. The natural features themselves can be used to construct a grid over the evidence. Fig. 8.31 shows an example of such a scene.



FIGURE 8.31
The natural grid technique would work here.

What is necessary to use the **Natural Grid** photogrammetry technique?

Clearly visible in the scene, there needs to be three lines: two that are vertical parallel lines and one that is perpendicular to the vertical parallel lines. While at the scene, you will have to measure one of the vertical parallel lines and the horizontal parallel line. In Fig. 8.31, the two requisite vertical parallel lines are the AC line, and the line going down from the B point that is cut off by the right side of the photograph. This image was intentionally composed to cut off this line to emphasize its length does not need to be known. Line AB is the required horizontal parallel line. The two necessary measurements are provided at the bottom of the image.

If you did not compose and photograph such an image at the original crime scene, you can still apply the natural grid technique to the photograph if you can return to the scene to collect the required measurements. In other words, you are now moving into an area where you may be able to extrapolate measurements from photographs you did not take. If anyone's photographs have these necessary elements in the photographs, you will be able to ultimately derive the measurements of the evidence within the photographs.

In Fig. 8.31, the wallet and the keys are enclosed in a huge rectangle measuring 80″ × 110″. Rectangles expand and reduce just as 2′ × 2′ squares do. All the same principles apply.

In Fig. 8.32, both the left and right vertical parallel lines have been extended until they intersect. Although the letter "D" has been drawn in at the lower right of the image, resist the temptation to assume the obvious line in the cement running along the bottom of the image will eventually be the CD line. The workmen who poured the cement pavement may not have been as precise as crime scene diagrammers may wish, as you will soon see. You will use photogrammetry to construct the 80″ × 110″ rectangle and not rely on concrete pourers.

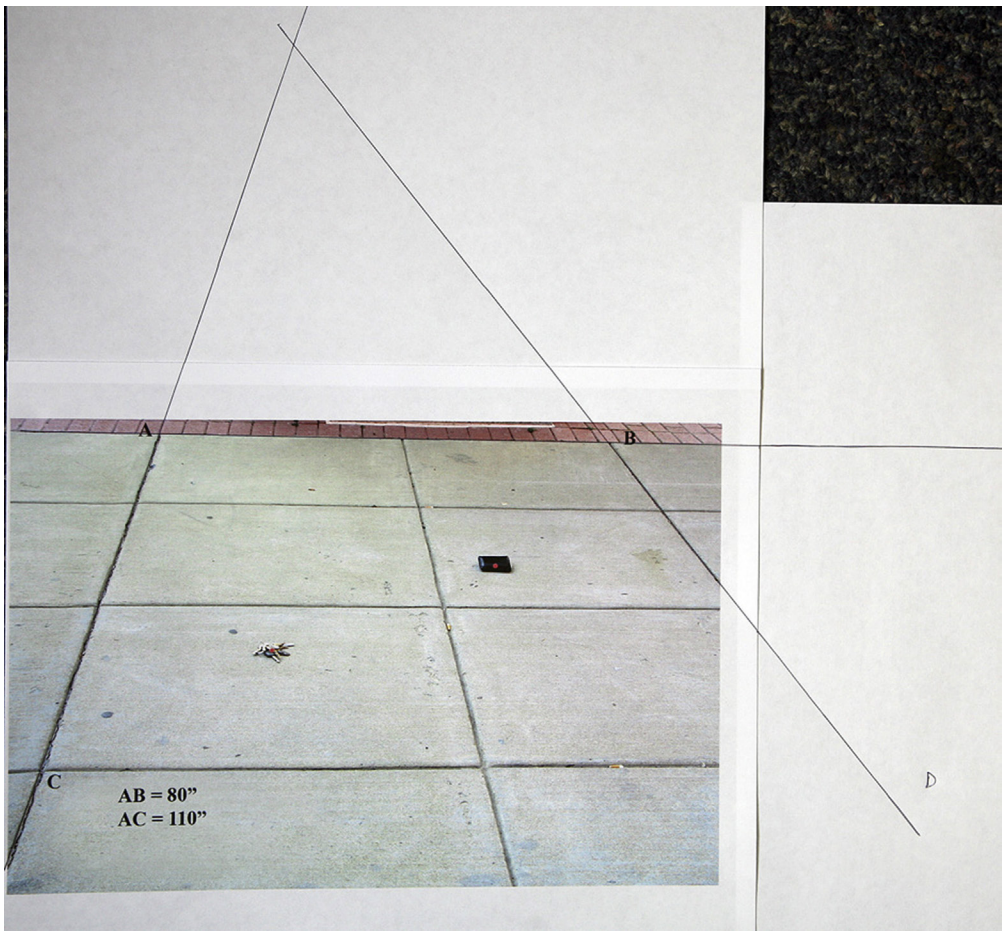


FIGURE 8.32
Vertical parallel lines extended until they intersect.

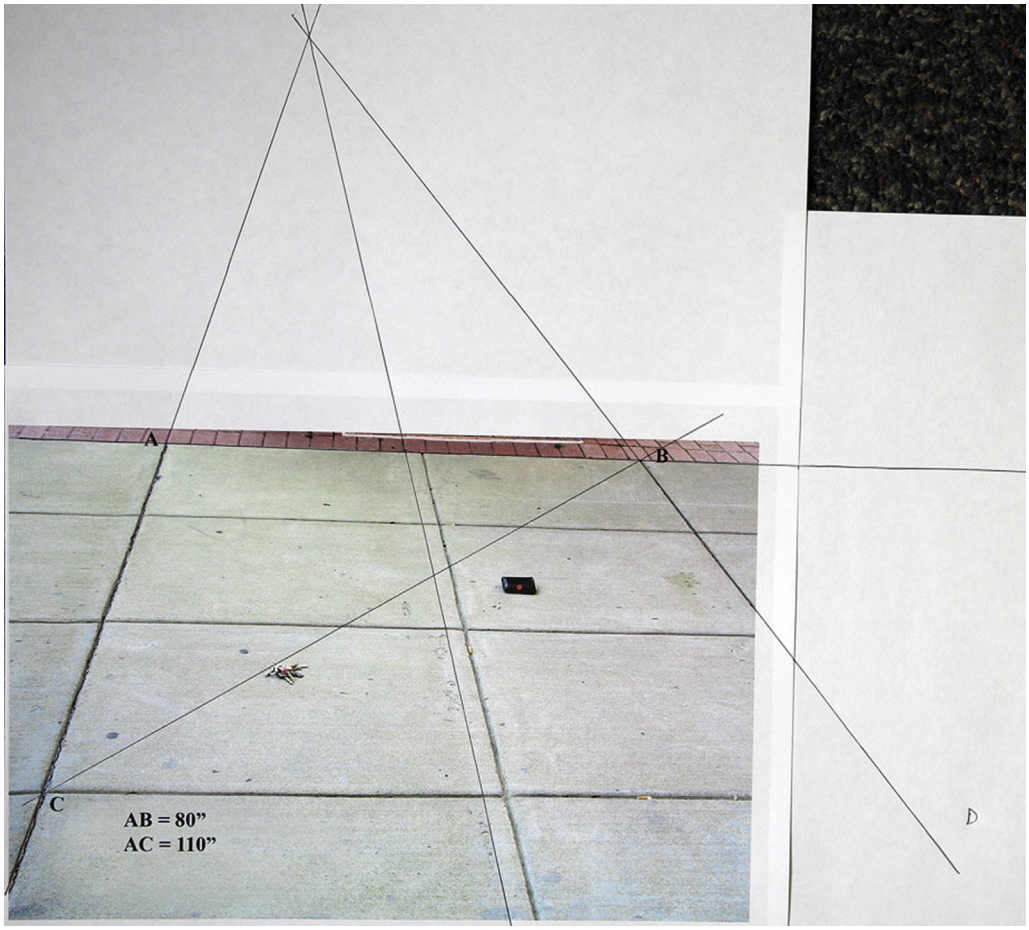


FIGURE 8.33
Determining the midpoint of the AB line and the larger rectangle.

Fig. 8.33 shows how the rectangle will eventually be completed. With the perspective grid technique, the original 2′ × 2′ grid already had a midpoint, formed by crossing the corners of the grid. In this example, the fourth corner is currently missing. To locate it, you can begin by measuring the length of line AB on the image you are working on and put a hash mark on the AB line at its halfway point. From the Y-intersecting point, you can draw a line through this hash mark, continuing to the bottom of the image. Notice how this new vertical parallel line does not align with the vertical line in the cement “midway” between point A and point B. Somehow the cement pourers did not locate that line properly. Now, point B and point C can be linked by a line. Finally, by connecting point A with the intersection of the BC line and the line coming from the Y point through the hash mark, you can now determine the D point. What you thought might be the CD line is not.

Fig. 8.34 shows the position of the D point of the rectangle. It is easier to trust the principles of geometry before relying on concrete pourers to help with your crime scene diagramming. Once the rectangle has been determined, it is smart to begin labeling the distance of each line. If you wait until many lines are drawn, it may be difficult or impossible to determine which line is which. From now on, as each new line is drawn, it will be labeled.

The 80″ × 110″ rectangle has been bisected vertically. It is now necessary to bisect it horizontally. The 80″ × 110″ rectangle has had its corners crossed; to bisect it horizontally, another rectangle will have to have its corners crossed.

Rather than constructing another 80″ × 110″ rectangle adjacent to the original rectangle, notice there are two 40″ × 110″ rectangles already drawn, separated by the line coming from the Y point through the middle of the original rectangle. In Fig. 8.35, the corners of the left 40″ × 110″ rectangle have been crossed, but rather than making a large “X” through the entire rectangle, only a small “x” has been made in the middle of the rectangle. With that “x” aligned with the “X” of the larger rectangle, the original rectangle can now be bisected horizontally. Both of these new lines can be labeled. The wallet and keys are now in 40″ × 55″ rectangles, and each is below the midpoint of the original rectangle.

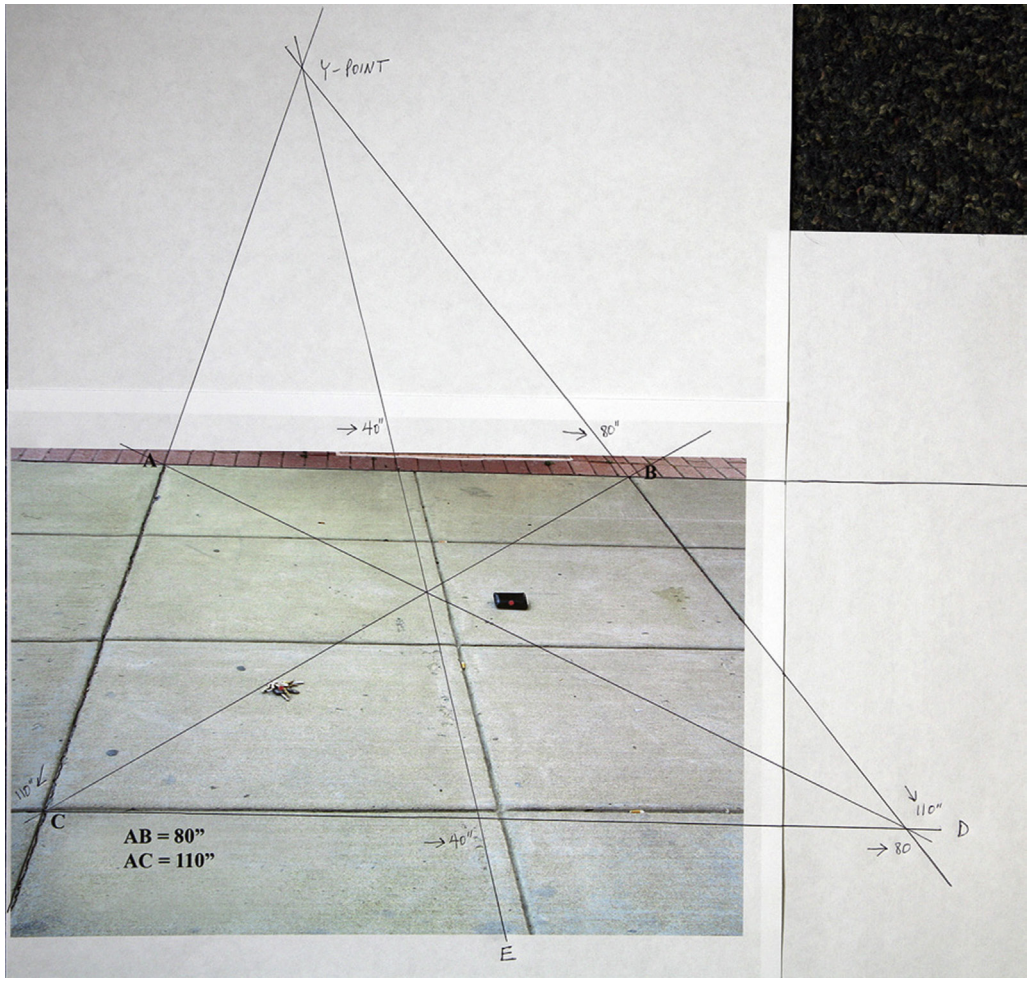


FIGURE 8.34
The D point located.

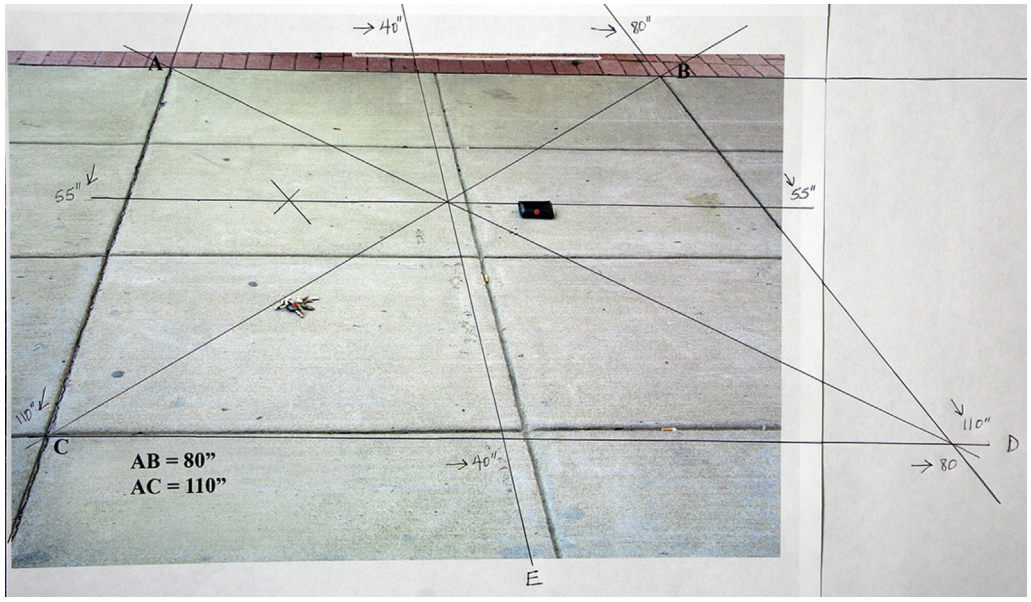


FIGURE 8.35
Bisecting the original rectangle horizontally, resulting in 40″ × 55″ rectangles.

Fig. 8.36 shows the result of crossing the corners of each 40′ × 55′ rectangle with evidence in it and bisecting each both vertically and horizontally. Each item of evidence is located in a 20″ × 27.5″ rectangle. Do not round the 27.5″ measurement up or down to an even 27″ or 28″. A rounding to the nearest inch is permissible only at the end, when the exact measurement of the evidence within the scene is determined.

Fig. 8.37 shows the result of crossing the corners of each 20′ × 27.5″ rectangle with evidence in it and bisecting each both vertically and horizontally. Each item of evidence is now located in a 10″ × 13.75″ rectangle. Again, retain all the decimal places of these measurements until the final determination of the evidence is made.

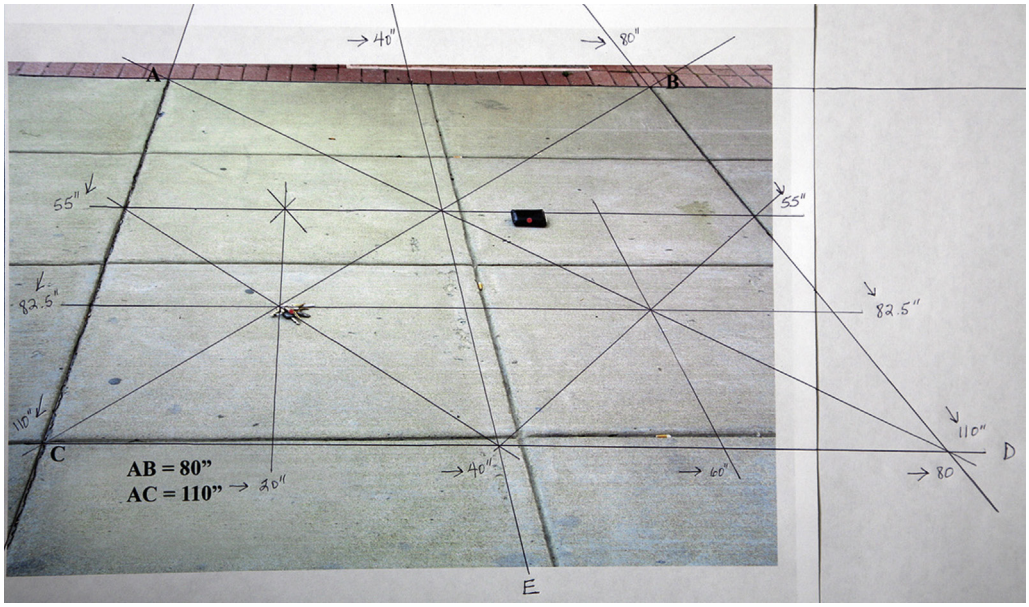


FIGURE 8.36
Bisecting rectangles again, resulting in 20″ × 27.2″ rectangles.

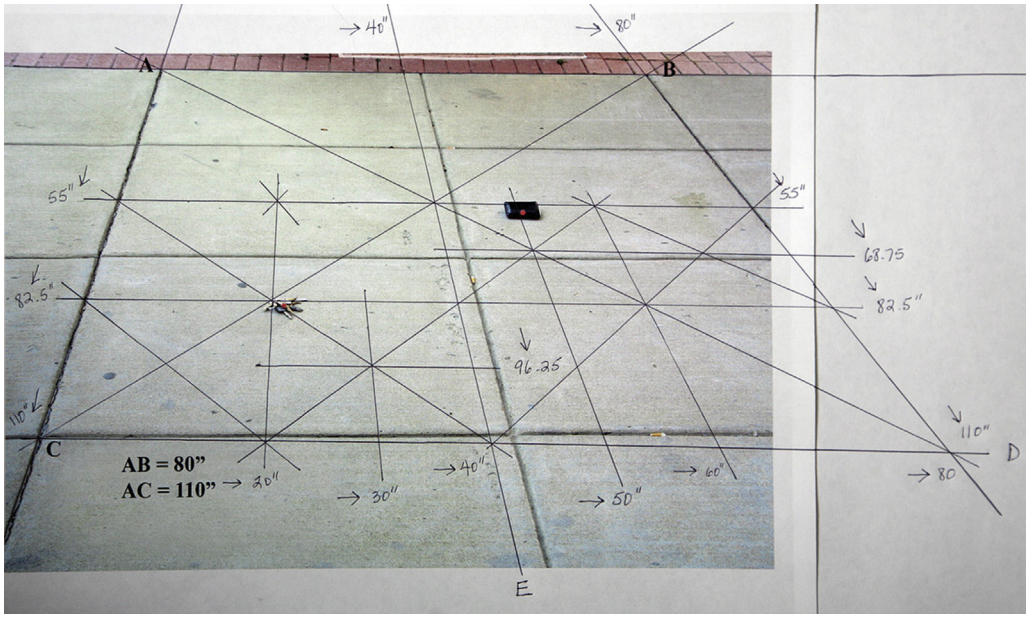


FIGURE 8.37
Bisecting rectangles again, resulting in 10″ × 13.75″ rectangles.

Fig. 8.38 shows the result of crossing the corners of each 10″ × 13.75″ rectangle with evidence in it and bisecting each both vertically and horizontally. Each item of evidence is now located in a 5″ × 6.875″ rectangle. Retain all the decimal places.

Fig. 8.39 shows the result of crossing the corners of each 5″ × 6.875″ rectangle with evidence in it and bisecting each both vertically and horizontally. Each item of evidence is now located in a 2.5″ × 3.4375″ rectangle. Retain all decimals.

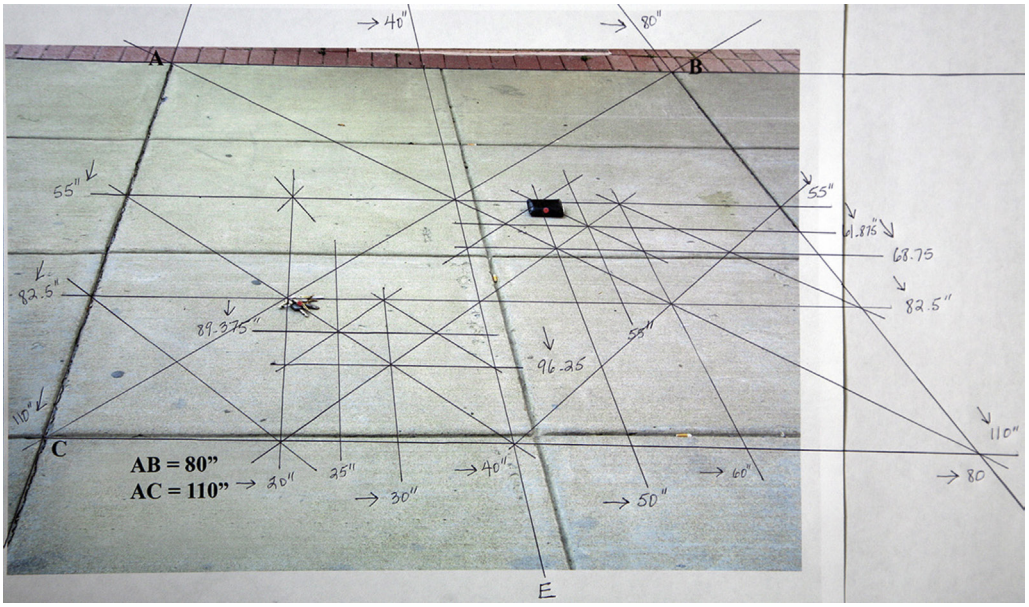


FIGURE 8.38
Bisecting rectangles again, resulting in 5″ × 6.875″ rectangles.

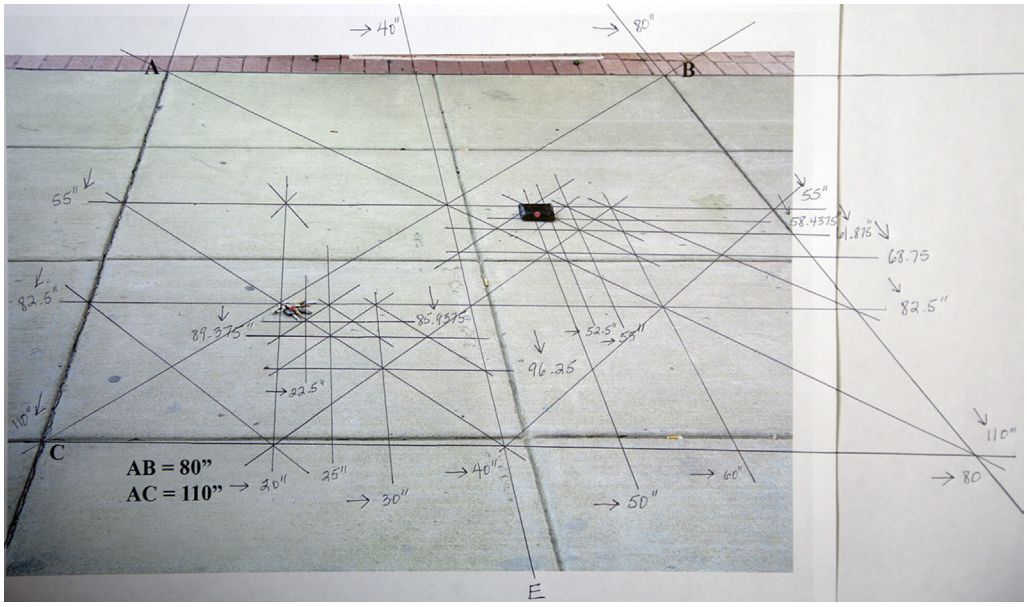


FIGURE 8.39
Bisecting rectangles again, resulting in 2.5″ × 3.4375″ rectangles.

Fig. 8.40 shows the result of placing three hash marks on both vertical and horizontal sides of the 2.5″ × 3.4375″ rectangle in which the dot representing the keys is located. These hash marks can be approximated. Once this is done, it will be easy to arrive at the whole numbers for the vertical and horizontal position of the keys. If you are seeking the distance from the A point in the original image, each horizontal hash mark is 20.833″ and 21.666″, respectively. Because the dot of the keys lies between them, 21″ E is the closest answer. Vertically, each hash mark stands for 83.6458″ and 84.7916″, respectively. As the dot of the keys aligns with the first hash mark nicely, that rounds up to 84″ as the closest answer. The keys are then 21″ E and 84″ S, or (21″, –84″) from the A point.

Fig. 8.41 shows the result of placing three hash marks on both vertical and horizontal sides of the 2.5″ × 3.4375″ rectangle in which the dot representing the wallet is located. These hash marks can be approximated. Once this is done, it will be easy to arrive at the whole numbers for the vertical and horizontal position of the wallet. If you are seeking the distance from the A point in the original image, each horizontal hash mark is 50.833″ and 51.666″, respectively. Because the dot of the wallet would intersect the first hash mark, that rounds up to 51″. Vertically, each hash mark stands for 56.1458″ and 57.2916″, respectively. Because the second hash mark would intersect the dot, that rounds to 57″ as the answer. The wallet is then 51″E and 57″S, or (51″, –57″) from the A point.

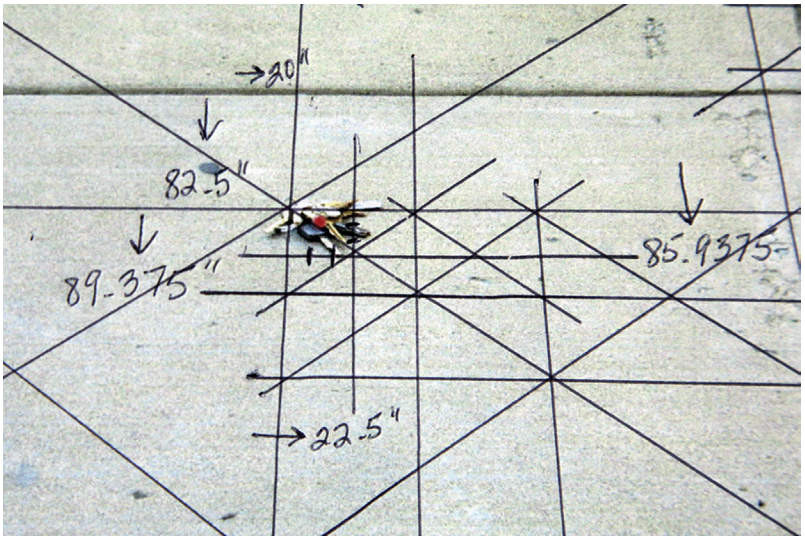


FIGURE 8.40
Rectangle with keys divided into thirds horizontally and vertically.

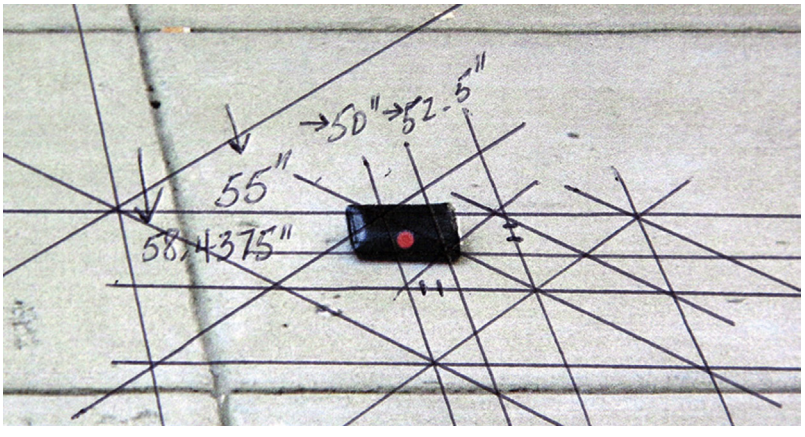


FIGURE 8.41
Rectangle with wallet divided into thirds horizontally and vertically.

REVERSE PROJECTION PHOTOGRAMMETRY

At times, your knowledge of photogrammetry will cause others to seek you out to help them extrapolate measurements from images relating to their crime scenes. You will first hope to find a perspective grid or a set of three perspective discs positioned in their images. If these are lacking, you will next look for natural grid elements in the crime scene image. If you come up with three strikes, are you out? No. There is still hope. The **Reverse Projection** photogrammetry technique may be applied to the crime scene photograph.

Some necessary elements have to be located within the crime scene photograph for this technique to be successful. In the crime scene image you are examining, there have to be sufficient fixed features present. Fixed features are scene elements that would still be present and easily visible if you were to return to the crime scene. The crime scene photograph cannot just include a number of items of evidence all positioned on an endless expanse of green grass or in a large parking lot with nothing but indistinguishable concrete surrounding the evidence. Clearly identifiable markings must be around the evidence. Fig. 8.42 shows an example. The four walkways are fixed at this scene and will be there until the entire area is bulldozed for a new building. Someone could return to the scene and easily find this alignment of walkways. If so, this author's badge case could easily be reinserted into the crime scene by reverse projection photogrammetry, and then it could be measured just as accurately as it could have been on the day of the original incident.

The term "reverse projection" needs some preliminary explanation. Is it not true that a "reverse projection" implies an "original projection"? Certainly. What is this "original projection"? The original projection was light rays reflecting from the original crime scene into a camera lens, where they formed an image on a digital sensor. Projected light rays from the crime scene formed an image.

You can now take an 8″ × 10″ enlargement of the original image and copy it onto a sheet of acetate with a copy machine. The result will be a transparency of the original 8″ × 10″ image. If you were to return to the original crime scene, you could walk around the scene with the transparency held up in front of your eyes, as in Fig. 8.43, until all the fixed features aligned perfectly. The only way for the fixed features of the scene to line up perfectly would be if the original position of the original photographer was eventually duplicated.



FIGURE 8.42
Outdoor scene perfect for reverse projection photogrammetry.

Duplicating this position is much easier said than done. To reapproximate the position the original photographer stood in when the original photograph was taken can take quite a bit of trial and error. Moving to the left and right, moving closer to the scene or farther away, and changing the distance the transparency is held in front of you can all be very frustrating. In addition to those gross positioning changes, one other consideration must be duplicated. The only way the scene will align perfectly is to view through the transparency from the height of the original photographer's eyes. If you are taller or shorter than the original photographer, the scene cannot align perfectly. Part of this process is to find out the eye height of the original photographer and to duplicate that height when viewing the crime scene through the transparency. Of course, you must view the transparency with only one eye open. If you take turns closing one eye at a time, you will notice the elements in the transparency "jump" to the left and right.

When this author is teaching the various photogrammetry techniques at GWU, reverse projection photogrammetry seems to be the students' least favorite technique. Mostly, it is presumed, because many have to stand on a pile of books or bend over for extended periods of time, making the process a bit cumbersome and uncomfortable. This technique is, however, just as accurate as the other photogrammetry techniques. It also has the benefit of being accurate on multiple planes rather than just the one plane where a perspective grid is placed.

Once you have aligned the fixed features, while viewing through the hand-held transparency, you will find the process will progress more smoothly if the transparency can be locked into place. This is done by placing the transparency in a clear plastic holder and clipping the plastic holder onto a tripod. Fig. 8.44 shows two clamps clipping the plastic holder onto a tripod head. The tripod quick-release, which screws onto the bottom of the camera, has been removed from the tripod to facilitate this.

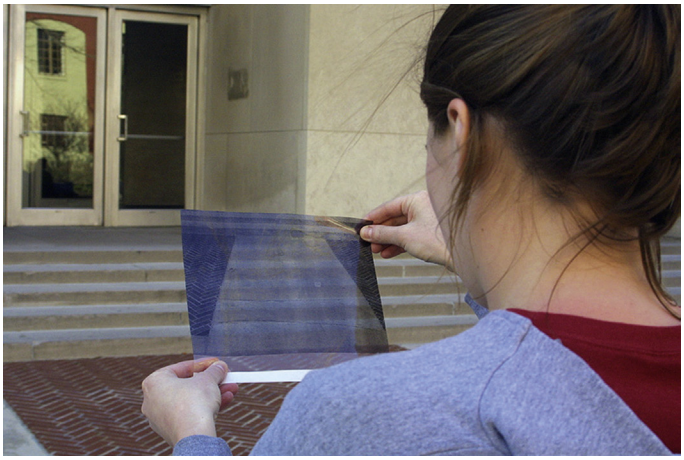


FIGURE 8.43
Viewing through transparency at a "crime scene."
Courtesy of Kelly Brockhohn, GWU MFS student.



FIGURE 8.44
Plastic holder with transparency clipped to a tripod.
Courtesy of Kelly Brockhohn, GWU MFS student.

Notice the alignment of the transparency. In effect, it must duplicate the angle of the digital sensor when the original image was captured. Because the camera was aimed down into the scene when the original image was captured, the transparency must also be placed in this position. It is important that you avoid "forcing" the alignment of the transparency and the crime scene by twisting the plastic holder so either side of the plastic holder is closer to the crime scene than the other side of the plastic holder. Although the transparency is tilted down, it must remain in the same orientation as the digital sensor when the original image was captured.

Once the fixed features of the crime scene are aligned with the fixed features of the transparency, the evidence in the original image can now be repositioned back into the crime scene. Fig. 8.45 shows the original scene with three items of "evidence" in it.

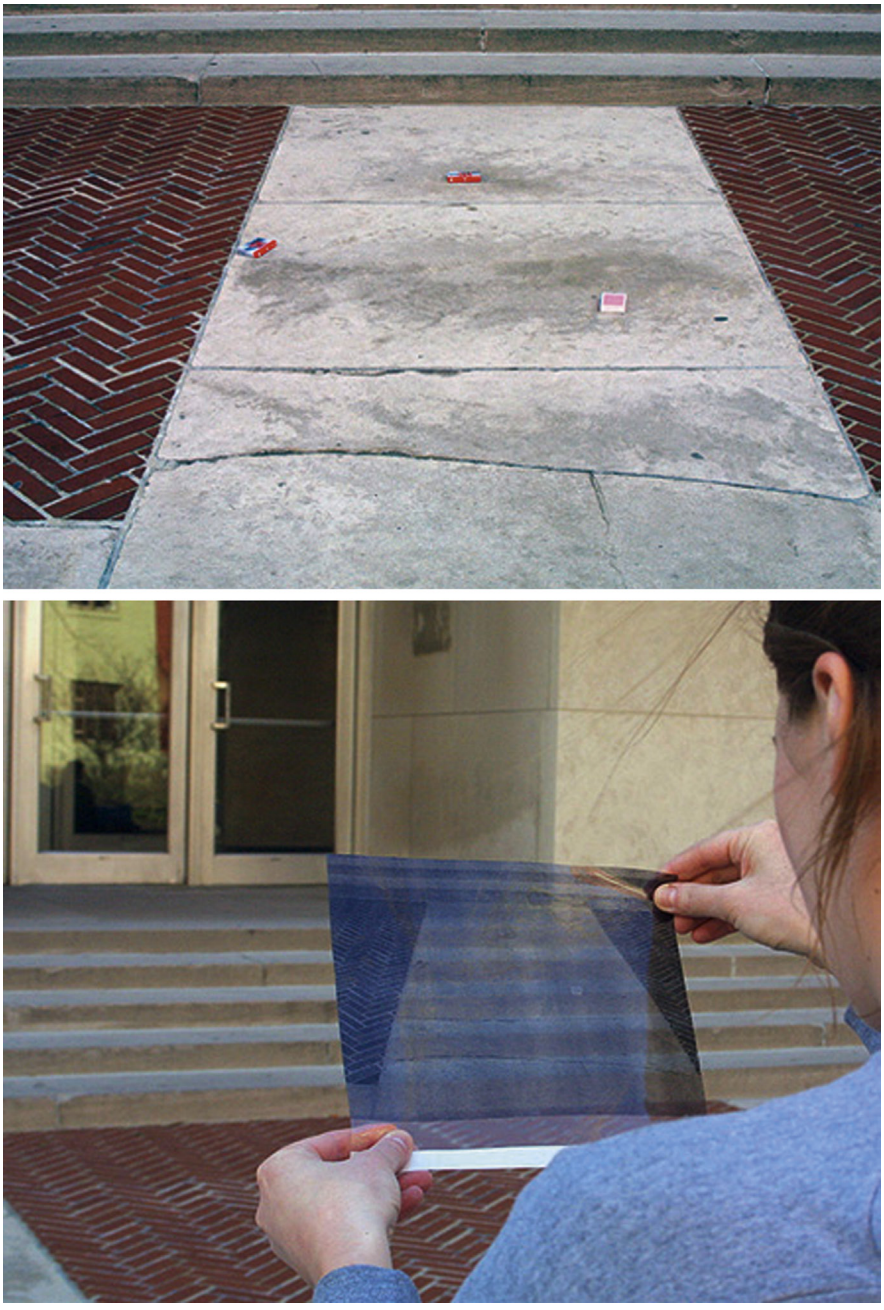


FIGURE 8.45
Aligning evidence in transparency with the crime scene.
Courtesy of Kelly Brockhohn, GWU MFS student.

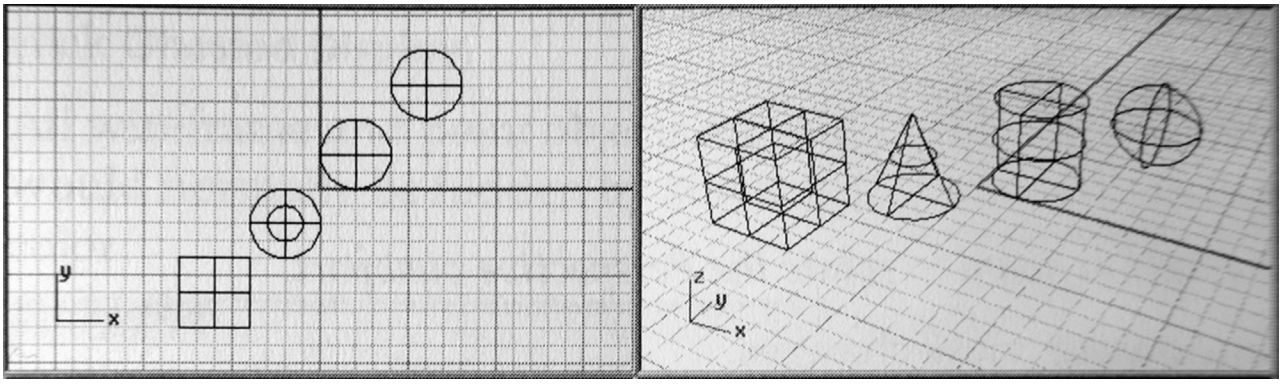


FIGURE 8.46
2D and 3D figures in Rhinoceros 3D.
Courtesy of Robert McNeel & Associates, Seattle, WA.

The transparency has those same items of evidence visible. At this point, you can have an assistant who move markers around the crime scene as you view the scene through the transparency. Direct the assistant by saying "forward," "backward," "left," or "right" until all the markers are aligned under the evidence in the transparency. Double-check that the fixed features of the transparency remain aligned over the fixed features of the crime scene. Once this has been completed, you have recreated the location of the evidence within the crime scene. Now, you can measure the evidence as you would have measured it at the original crime scene.

The FBI uses a more sophisticated variation of reverse projection photogrammetry to determine the height of bank robbers and to determine the length of sawed-off shotguns photographed by surveillance cameras in banks. The version explained in this chapter is very simplified.

RHINO PHOTOGRAMMETRY

As intriguing as these photogrammetry techniques are, for years this author has been searching for a way to simplify the entire process. Earlier in this chapter, you saw the question "Would it not be nice if we could superimpose a uniform checkerboard grid system, like 1′ × 1′ squares, over the entire crime scene?" Many software programs have grid systems as a part of their packages. Perhaps one of these grid systems could be adapted so it could be superimposed on any crime scene photograph.

The first task was to determine the minimum number of reference points needed in a crime scene photograph to "lock" a grid system to the photograph. Of course, a perspective grid has four corners. Requiring four rectangular points of reference in a crime scene photograph returns us to the natural grid technique. Could this be simplified? Perhaps three points of a right triangle would enable a grid system to be "locked" to a crime scene diagram. It was then realized that three points of a right triangle are really just a variation of a rectangle, with one corner missing. The system needed to be less restrictive. How about any three points of any triangle? It would be enormously convenient to be able to develop a method of extrapolating crime scene measurements from any photograph with only three fixed features anywhere in the image.

A search was begun for robust grid systems in software programs that might fill the bill. After much searching, this author found Rhinoceros 3D.[1] As such, **Rhino Photogrammetry** allows you to create 3D objects and view them from any perspective. It has a grid system for determining the size and proportions of any object created. This grid system will be utilized and eventually superimposed over crime scene images.

Fig. 8.46 shows objects in the Rhino software viewed in their "top" window, which is equivalent with a bird's-eye view of the objects, and in their "perspective" window, which is the same view you would have of the objects standing nearby. These two grid systems will be used with a mock crime scene to determine the accuracy of the software. The evidence will be measured traditionally, so the "correct" answers are already known.

[1]Rhinoceros is a modeling software program used primarily to draw 3D objects. It was the software program used to partially model the Titanic for the movie (http://www.rhino3d.com/).

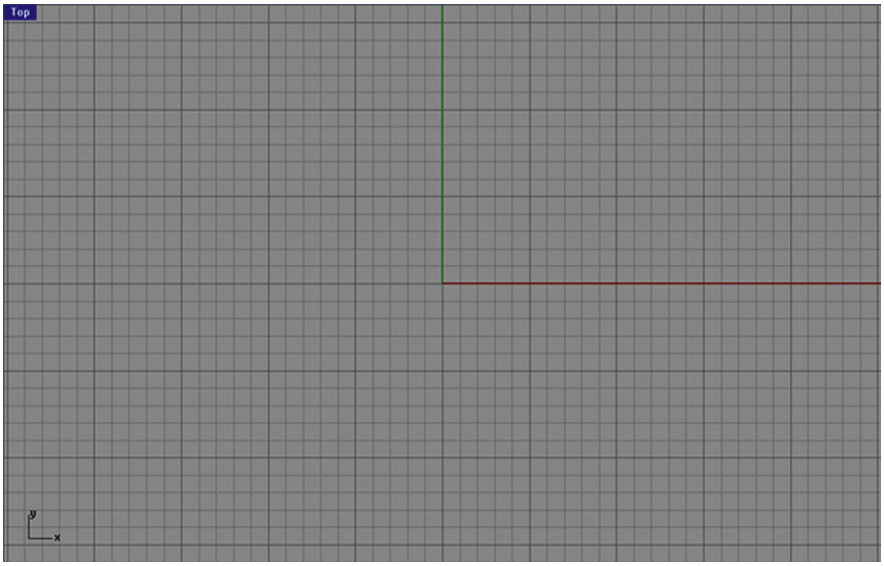


FIGURE 8.47
Rhinoceros 3D top view of grid.
Courtesy of Robert McNeel & Associates, Seattle, WA.

Fig. 8.47 shows the top view of the grid system again. It is very much like the way crime scene diagrams should be laid out; the crime scene and evidence are all that are lacking. It is also very much like draft paper with grids on it. On the top view, you will eventually locate the three known reference points in scale. The squares shown can be considered meters, feet, or any "units" of your choice. When the cursor is placed anywhere over the grid system, x and y coordinates are indicated at the bottom of the scene, with an accuracy to three or four decimals. The (0,0) point of the grid is the intersection of the primary vertical (*green*) and primary horizontal (*red*) lines as shown.

Tools allow the perspective grid to be rotated to the left and right, as in Fig. 8.48, or zoomed in and zoomed out as in Fig. 8.49.

When Rhino 3D is first opened, a "Top" view and "Perspective" view window can be seen, each with a checkerboard grid system in them (Fig. 8.50). The Top view is similar to a bird's-eye view of a crime scene. The Perspective view is a view of the same scene from a photographer's point of view.

The three dots shown in each scene are just examples showing that when dots are added to one viewpoint, they are also added to the other viewpoint. These dots have also been enlarged and colored to make them more easily seen.

Back at the crime scene, if you can anticipate that Rhino photogrammetry, as we will call it, is going to be applied to an image, there should be three fixed features easily recognized within the crime scene. In this case, Fig. 8.51, a mock crime scene image, containing multiple items of evidence, is captured with a digital camera. The three fixed features of the scene are circled. At the base of the black pole, top left, a penny has been put down to represent the point where vertical brick lines would strike the base of the black pole if continued.

If present at this crime scene, intending to use Rhino photogrammetry later, the distances between the three fixed features can immediately be measured. If one is asked to extrapolate the locations of the evidence within the crime scene at a later date, one must be able to return to the scene, locate any three fixed features shown in the image, and measure them.

The three fixed features do not have to form a right triangle. Any triangle is permissible.

Once the known triangle at the crime scene has been measured, it can be recreated in Rhino's "Top" view, Fig. 8.52.

The checkerboard grid system is set up in groups of 5×5 units. These can be any convenient increments, feet and inches, or metric measurements. If using feet and inches, the inches should be converted to decimals. 4′6″ should be converted to 4.5′.

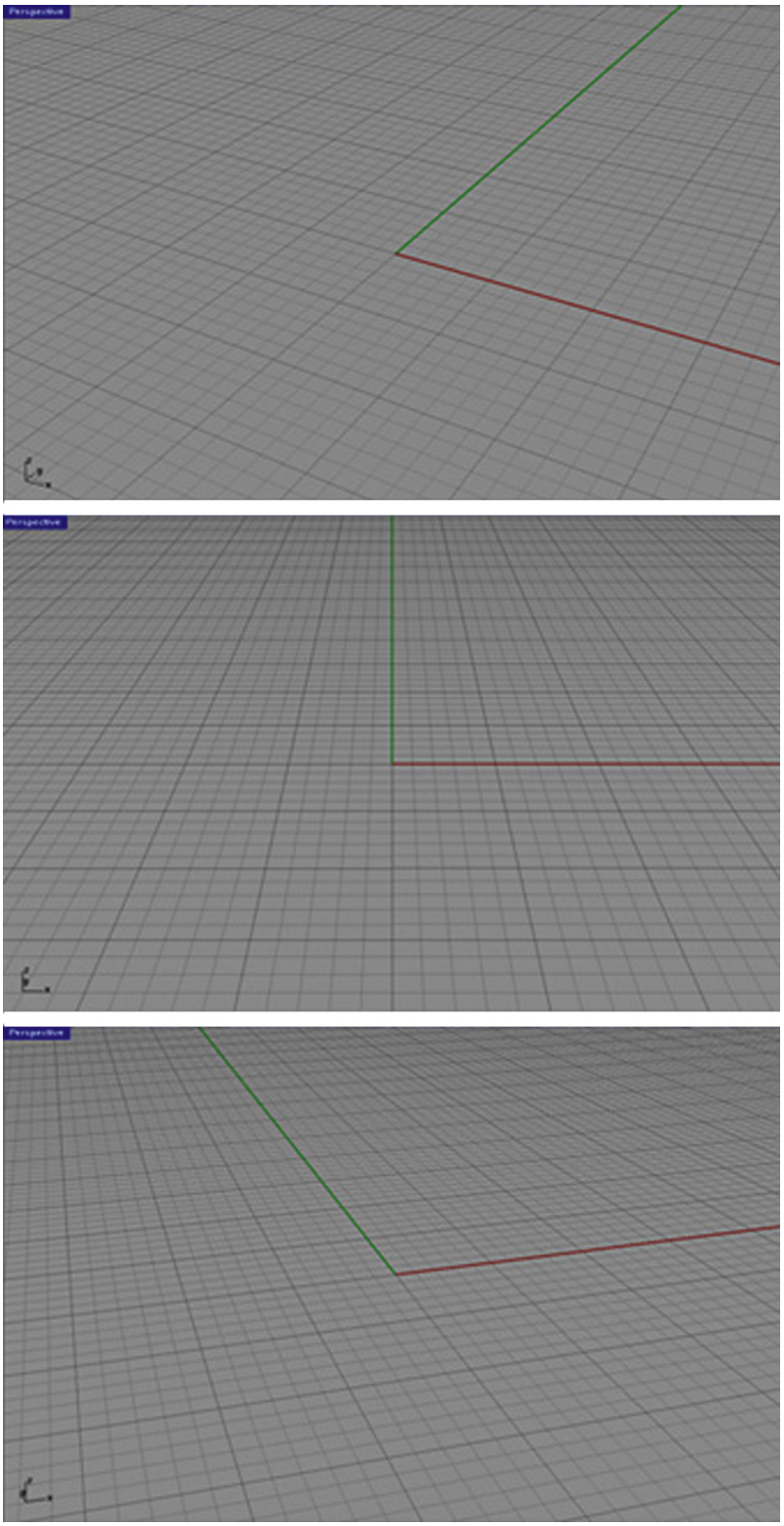


FIGURE 8.48
Rhinoceros 3D perspective view of grid.
Courtesy of Robert McNeel & Associates, Seattle, WA.

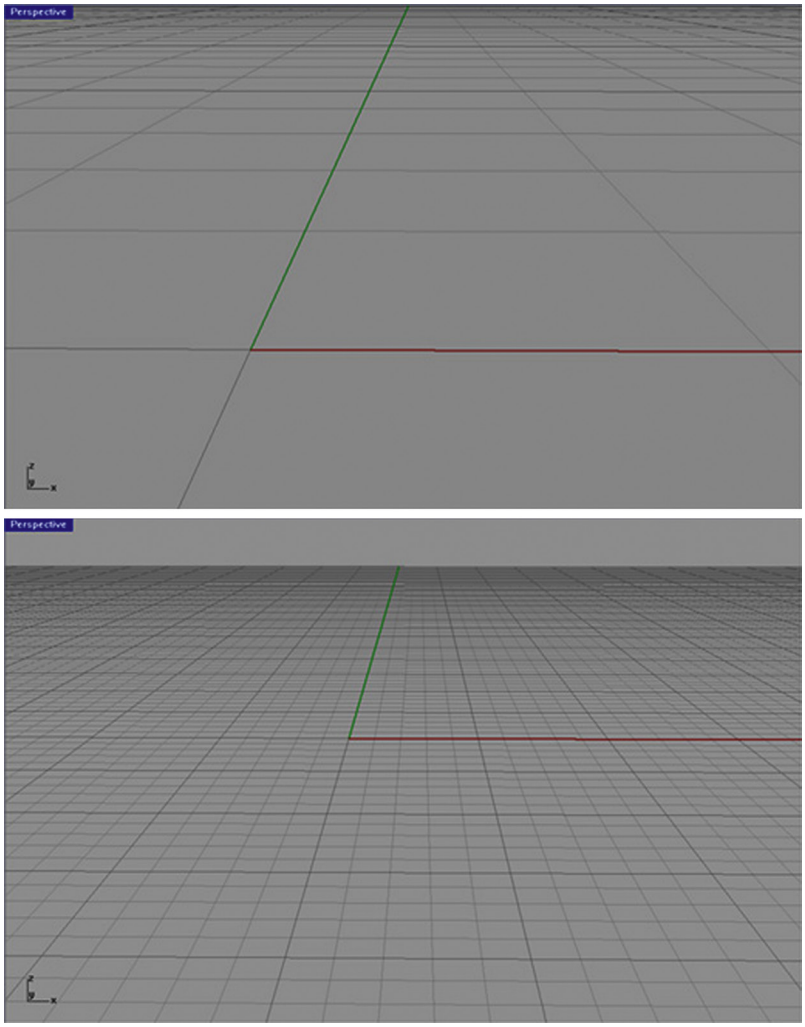


FIGURE 8.49
Rhinoceros 3D perspective view of grid, zoomed in and zoomed out.
Courtesy of Robert McNeel & Associates, Seattle, WA.

One dot should be inserted where the green and red lines intersect, the (0,0) of the checkerboard grid system, with the red line being the X-line and the green line being the Y-line of an x-y coordinate system. A second dot representing another fixed feature is added to either the red or green line. In this case, the second dot representing a fixed feature is exactly 5′ from the first dot and is placed directly above the first dot.

To locate the third dot representing the third fixed feature, two circles will be constructed. From the first dot to the third dot, the distance was 6′ 10.5″ or 6.875′. A two-point circle is begun by beginning the circle at the first dot. The distance from the first dot to the third dot is entered into the Rhino software as the radius of a circle whose midpoint is the first dot. Hit "enter" and the circle is automatically placed into the top view. It is the larger of the two circles shown.

The distance from the second dot to the third dot is 4′6″ or 4.5′. A new two-point circle is begun with the second point as the center of this circle. Enter 4.5′ as the radius of this new circle, hit "enter," and the new circle is automatically inserted into the Top view. Where these two circles intersect, the third dot representing a fixed feature can be inserted.

These same dots and circles are also seen in the Perspective view (Fig. 8.53).

The circles are no longer needed and can be eliminated. Fig. 8.54 is the Top view. The three dots are now called the "Rhino Triangle."

Fig. 8.55 is the Perspective view with the circles eliminated. The orientation of the Rhino Triangle has been "rotated" to better align with the original crime scene image.

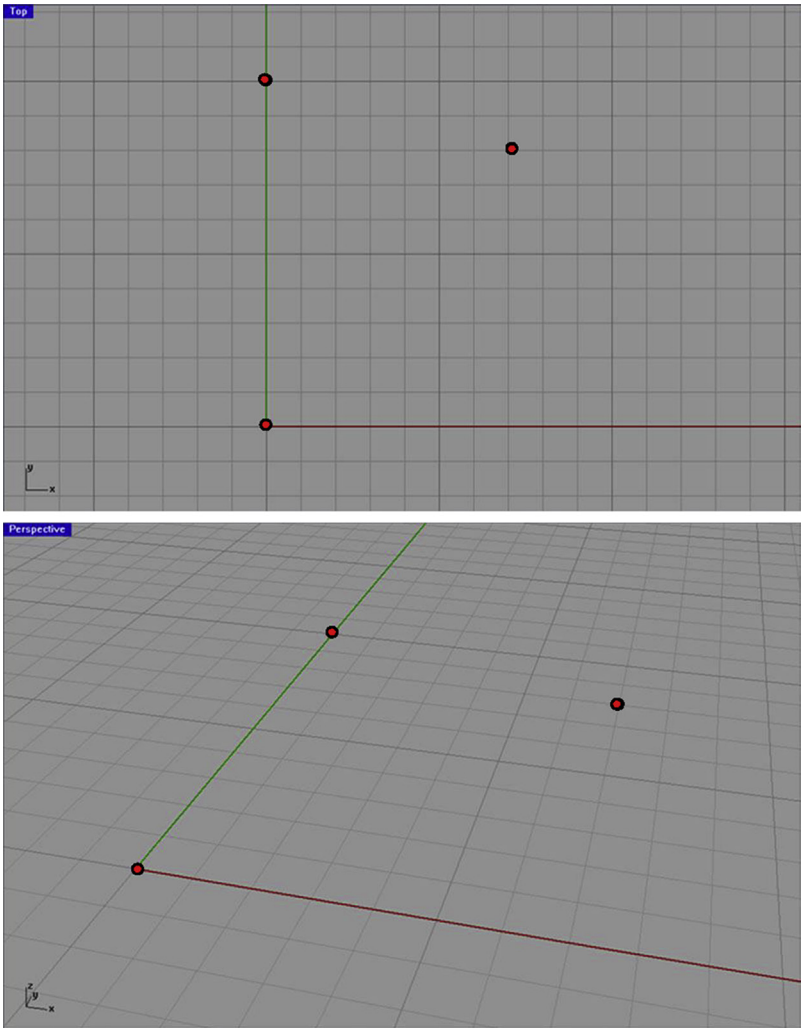


FIGURE 8.50
Rhinoceros 3D Top and Perspective views of the same points.
Courtesy of Robert McNeel & Associates, Seattle, WA.



FIGURE 8.51
Mock crime scene with three fixed features circled.

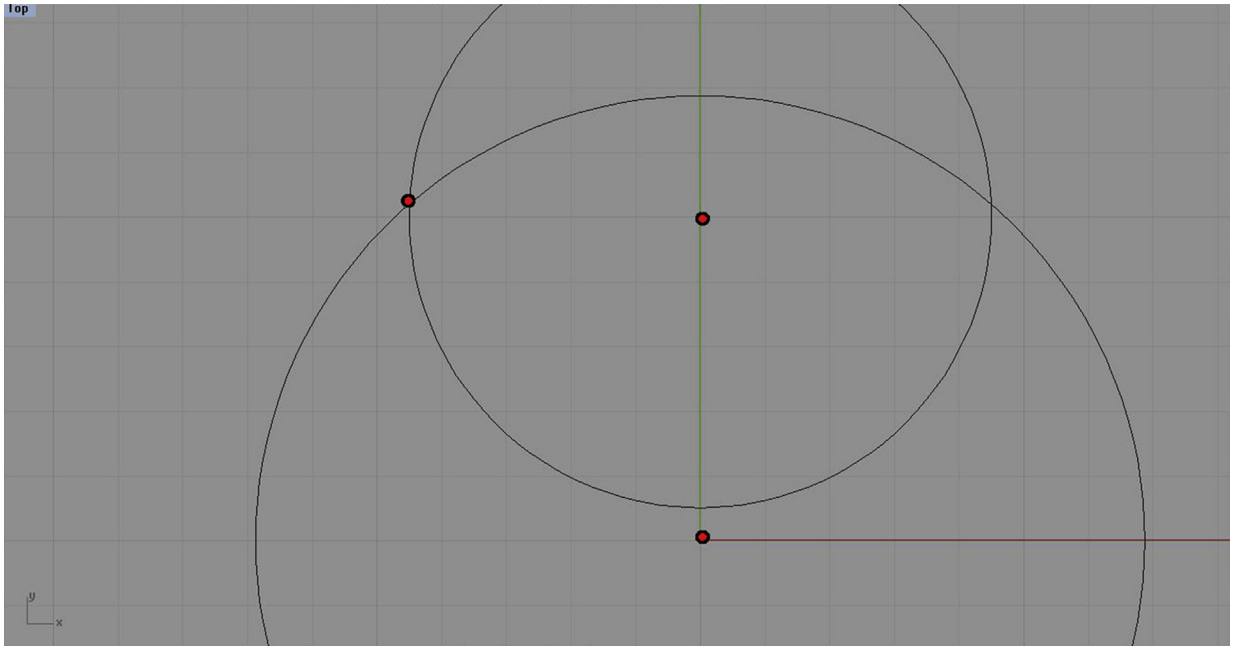


FIGURE 8.52
Known measurements of fixed features added to the Rhino grid, Top view.
Courtesy of Robert McNeel & Associates, Seattle, WA.

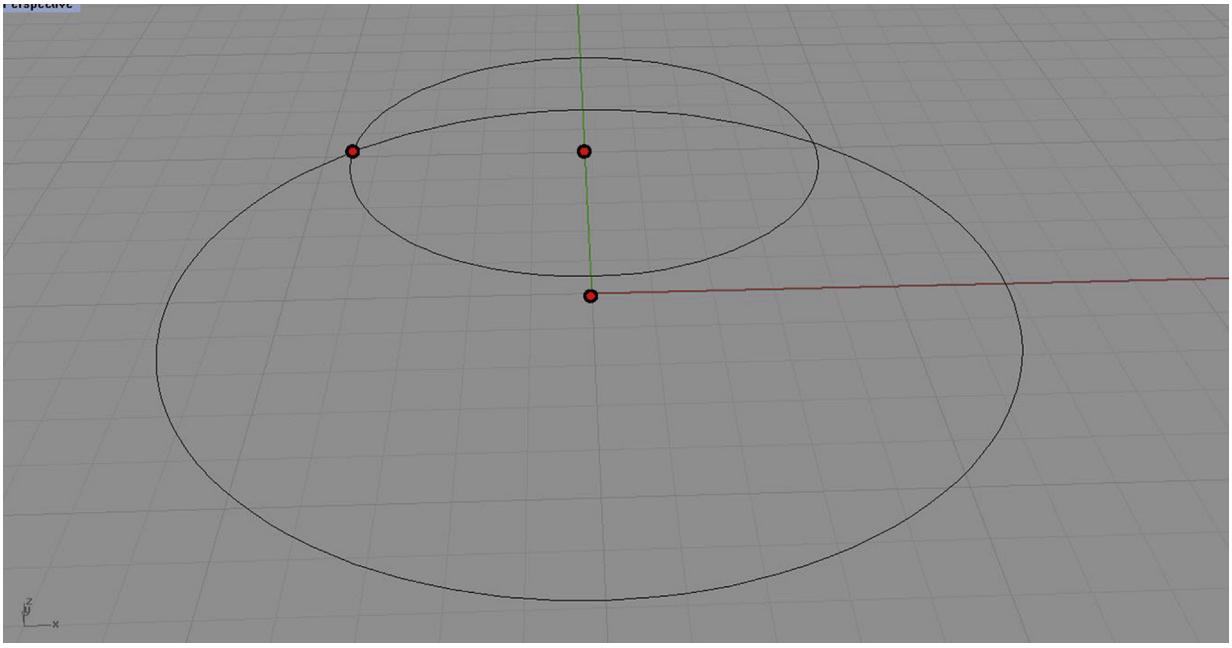


FIGURE 8.53
Known measurements of fixed features added to the Rhino grid, Perspective view.
Courtesy of Robert McNeel & Associates, Seattle, WA.

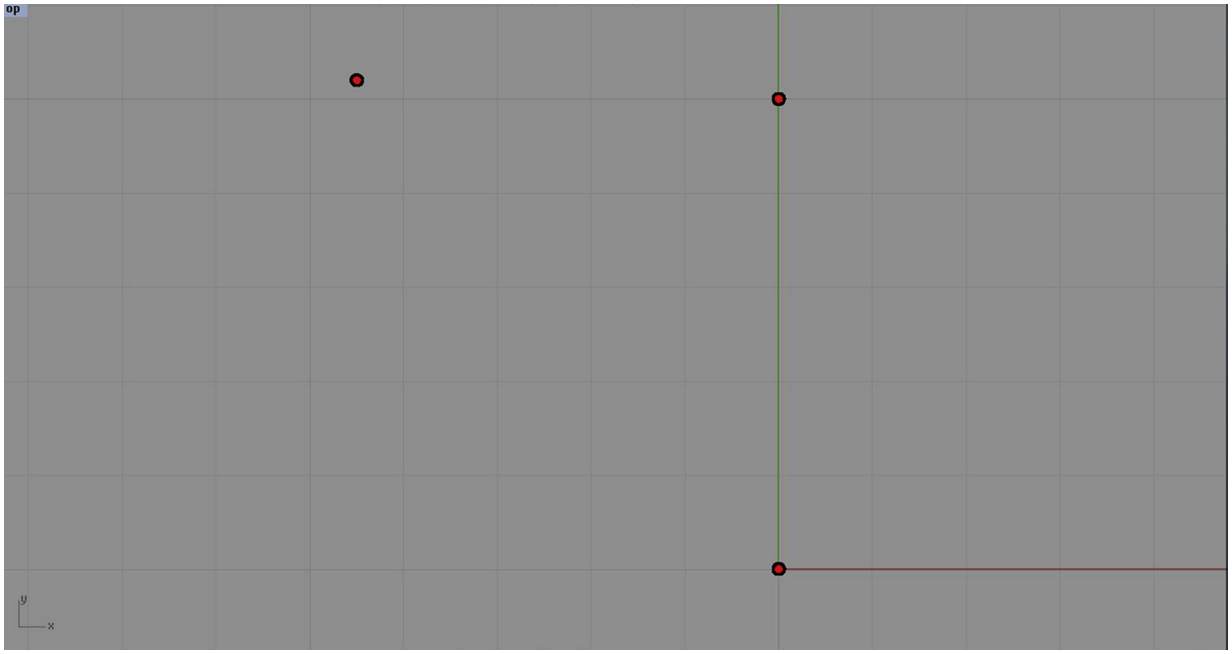


FIGURE 8.54
Perspective view, circles eliminated.
Courtesy of Robert McNeel & Associates, Seattle, WA.

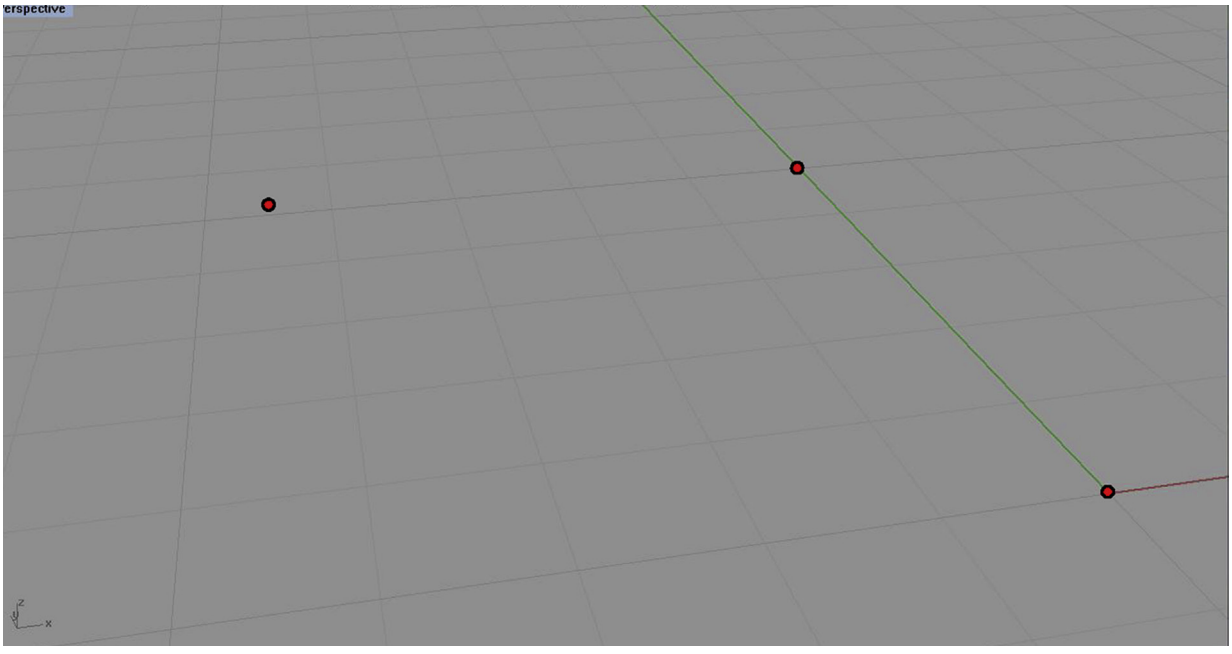


FIGURE 8.55
Perspective view, triangle rotated to approximate crime scene layout.
Courtesy of Robert McNeel & Associates, Seattle, WA.



FIGURE 8.56
Rhinoceros 3D perspective view of grid superimposed over a mock crime scene.
Courtesy of Robert McNeel & Associates, Seattle, WA.

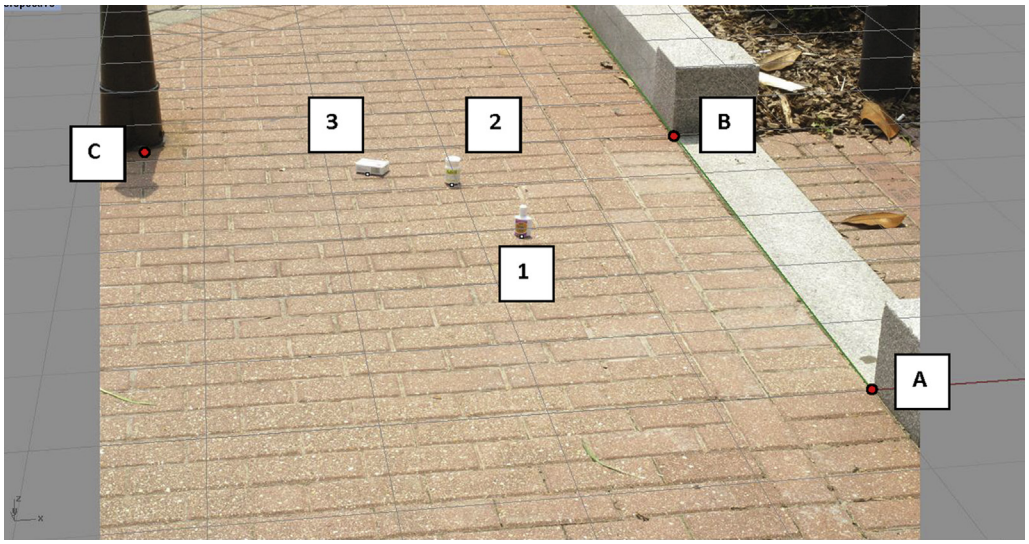


FIGURE 8.57
Rhino fixed features superimposed over the fixed features.
Courtesy of Robert McNeel & Associates, Seattle, WA.

See Fig. 8.56. The crime scene image is imported as background wallpaper under the Rhino grid system. It is now necessary to adjust the Rhino Triangle dots until they superimpose over the actual fixed features of the crime scene image. This is done by rotating the grid system, enlarging or reducing the grid system, and dragging the grid system as desired.

The end result shows the Rhino Triangle dots superimposed over the fixed features of the scene. In Fig. 8.57, three new dots have been added to the front center of the three items of evidence. These edges are definitely discernable and are used instead of the center of mass of the evidence.

The Rhino software has an "analyze distance" command. Click on any point within the image and drag the cursor to any other point within the image and the distance is indicated. For instance, from the dot at the intersection of the *red* and *green* lines (A) to each of the items of evidence is as follows:

A–1 = 3.321′
A–2 = 4.541′
A–3 = 5.166′

From the dot 5′ above (A), which will be called (B):

B–1 = 2.695′
B–2 = 2.237′
B–3 = 2.738′

These are the equivalent of triangulating the evidence from two fixed features with tape measures. If traditional measurements were done at his crime scene, six measurements would have been necessary for the evidence plus the measurements of the crime scene itself.

With Rhino photogrammetry, only three measurements were made, and the scene, as well as the evidence, can be placed into a scale diagram. The Top view of Rhino 3D (Fig. 8.58) shows the crime scene and the three items of evidence all in scale.

How accurate were the measurements? All the measurements were less than 1″ off the known measurements. You might ask, "How accurate were the measurements obtained with the tape measure?" The original measurements were rounded to the nearest inch, as has been this author's practice for decades. Of course, the accuracy of the original measurements could be debated, but what technique could be used to check the accuracy of the tape measurements? Bring in another tape measure? Total Station? Regardless, this author is satisfied.

It must be added that a camera with a full-frame digital sensor was used for this exercise. A Canon EOS 5D, a 12.8-MP camera, with a zoom lens set to 50 mm was used.

It has been noticed that digital cameras with focal length multipliers have posed some problems, which cannot be explained yet. A Canon D60 has a smaller digital sensor, with a 1.6 focal length multiplier. That means a 50 mm lens gets cropped similar to the view from an 80 mm lens. When 80 mm is indicated in the Rhinoceros software as the focal length of the camera used, the measurements have not been correct. At times, it has been necessary to "tweak" the software program and indicate either a 79 mm or an 81 mm lens has been used to obtain measurements close to the known measurements. One possible obvious explanation may suffice. When camera manufacturers attribute a focal length designation to a lens, just how precise are they? It may be that the precision of the Rhino software is able to detect "nominal" focal length variations.

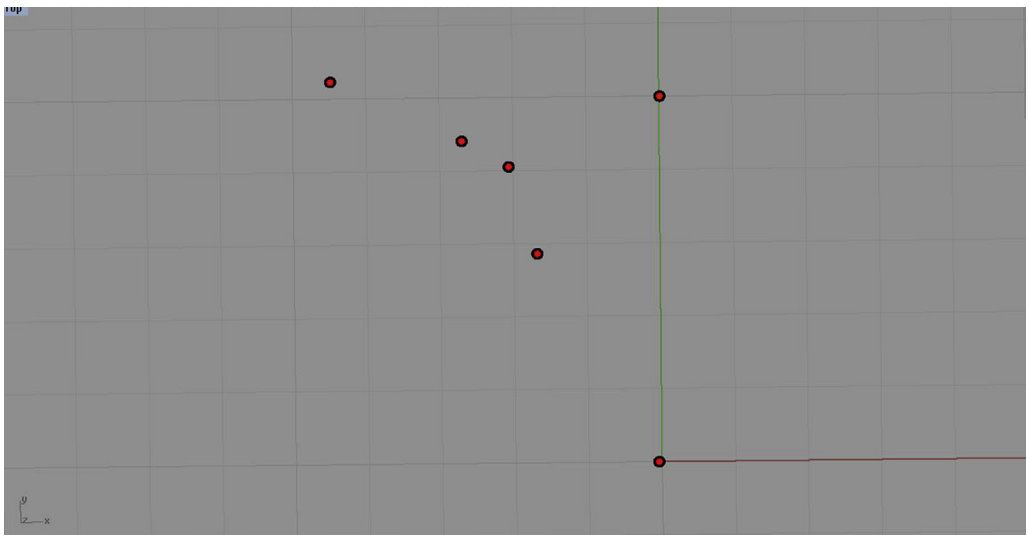


FIGURE 8.58
Rhino Top view: a crime scene bird's-eye view.
Courtesy of Robert McNeel & Associates, Seattle, WA.

This author first learned about photogrammetry in 1988, while studying at the Virginia Forensic Science Academy. Realizing its potential to help get the job as a crime scene investigator done, the author used it at all important crime scenes. Figs. 8.59 and 8.60 are just two more examples of its use at real crime scenes. Fig. 8.59 was at a triple homicide, and the perspective grid was used to locate the bloody shoe print near one of the victims. Fig. 8.60 was a different homicide scene, with evidence around the victim. The defendants in both of these cases will not be able to view these images in this book because they are no longer living.



FIGURE 8.59
Perspective grid used at a triple homicide scene.
Courtesy of the Arlington County Police Department, Arlington, VA.

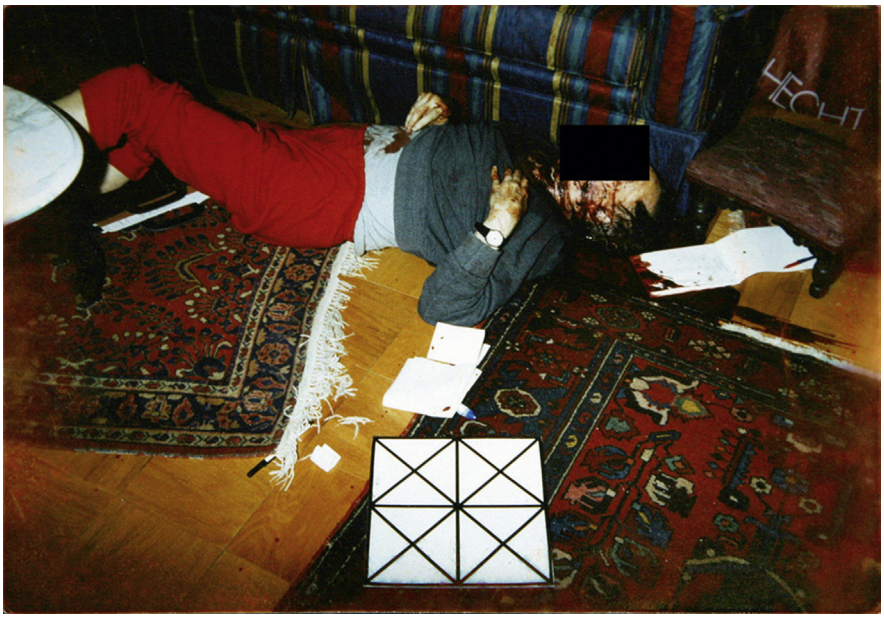


FIGURE 8.60
Perspective grid used at a homicide scene.
Courtesy of the Arlington County Police Department, Arlington, VA.

Photography can record life, as well as crime and accident scenes. With photogrammetry techniques, photography can also be used to extrapolate the precise measurements of the items within a photograph.

Before leaving this photogrammetry chapter, it must be mentioned that Rhinoceros 3D software is not necessary to do the equivalent of Rhino photogrammetry. An NCIS Special Agent has been using freeware called SketchUp. It has a great grid which works much like Rhinoceros 3D. And, it has an upgrade which can be purchased if you really get hooked on it.

Now, we just need to figure out how to get DNA from photographs! I guess there *is* "touch" DNA!

SUMMARY

Most crime scenes, and the evidence within them, are measured with tape measures so that crime scene diagrams can be constructed. As the crime scenes or accident scenes become larger and more elaborate, many departments use sophisticated laser sighting systems combined with computer software, like Total Station, to create very detailed maps of the scenes. Highly trained FBI image analysts can also extrapolate bank robbery subject heights and shotgun lengths with very sophisticated photogrammetric techniques.

On many occasions, however, the personnel of local law enforcement agencies can use very elementary photogrammetric techniques. Basic photogrammetry techniques can help determine the location of evidence at smaller crime scenes. This chapter demonstrated various simple photogrammetry techniques that can help local crime scene technicians "get the job done."

Photogrammetry can be another tool on the Bat-Belt of crime scene photographers.

DISCUSSION QUESTIONS

1. Briefly describe the general concept of photogrammetry.
2. All the basic photogrammetry techniques rely on the ability to superimpose a grid system over a crime scene and the evidence within it. Discuss two of the variations by which this can be done.
3. Some of the photogrammetry techniques mentioned apply to a crime scene photographer originally present at a crime scene, when a grid or discs can be inserted into the crime scene photographs. Some apply to attempting to obtain measurements from a photograph after the scene has been cleared, and no grids or discs are in the images. Which techniques apply to the latter?

EXERCISES

1. In an area approximately 10′ × 10′ square, place three items of "evidence." Place a 2′ × 2′ perspective grid in the same area. This can be four 1′ × 1′ floor tiles laid adjacent to each other. Ensure that the full perspective grid and all three items of evidence can be composed in the viewfinder by use of an SLR camera with a 50 mm lens. Compose the scene so the grid is low and centered in the field of view. Take that photograph. Lay a tape measure from the (0,0) point of the perspective grid (the middle of the lower edge) up through the middle vertical line of the grid into the scene. The tape measure is both the Y-line of the perspective grid, and it is the baseline by which all three items of evidence will be measured by baseline coordination. With the tape measure positioned like the Y-line of the grid, determine the measurements of each item of evidence. Rather than measuring "center of mass," place a coin at the middle of the side of each item of evidence closest to the grid. These coins will represent each item of evidence. These measurements will be the "known answers" that the grid measurements will be compared with. Have the photograph printed and then enlarge it to approximately 8″ × 10″ on a copy machine. Follow the directions in the chapter for extending the 2′ × 2′ grid squares over the scene until all three items of evidence are within a 2′ × 2′ grid extension. Reduce the 2′ × 2′ squares containing each item of evidence to 1′ × 1′ squares, then 6″ × 6″ squares, and then to 3″ × 3″ squares. Determine the location of each coin representing the evidence to the nearest inch. Compare with your known measurements. The first time this is done, your answers should be within 2″ of the known distances. Repeat this exercise, having the mock crime scene larger each time, until areas of 25′ × 25′ routinely are used and the accuracy of each item of evidence is within 1″ of the known.
2. Find an area where there are two parallel vertical lines and at least one horizontal line that is perpendicular to the parallel vertical lines. Place three items of evidence within this scene. Compose this scene with an SLR camera with a 50 mm lens so that the horizontal line runs horizontally through your field of view. Take the

photograph. Measure one of the vertical lines and the horizontal line. Consider this intersection of these two lines as the (0,0) point of an (x,y) coordinate system and measure all three items of evidence to the (0,0) point. Have the photograph printed and then enlarge it to approximately 8″ × 10″ on a copy machine. By use of the natural grid technique demonstrated in this chapter, construct a large rectangle around the evidence and then reduce the size of this rectangle until the distance of all three items of evidence to the (0,0) can be determined. Repeat this exercise, having the mock crime scene larger each time, until areas of 25′ × 25′ routinely are used and the accuracy of each item of evidence is within 1″ of the known.

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CHAPTER 9

Special Photography Situations

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Crime Scene Photography. http://dx.doi.org/10.1016/B978-0-12-802764-6.00009-X
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SUBCHAPTER 9.1

Aerial and Elevated View Photography

Doug Middlebrooks, Keith Dobuler, Tammy Russell
Fairfax County Police Department, Fairfax, VA, United States

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the optimal conditions for doing aerial photography.
2. Explain the optimal camera variables that should be used with aerial photography.
3. Understand the safety concerns that apply whenever taking aerial photographs.

AERIAL AND ELEVATED VIEW PHOTOGRAPHY

Aerial photography is the capturing of images from an aircraft while in flight. A variety of platforms are available to take aerial photographs to include fixed and rotor wing aircraft (planes and helicopters) and unmanned aerial vehicles (UAVs; drones). Elevated view photography is capturing images from above "eye level" or the natural perspective. These photographs are taken from rooftops, ladders, fire department tower trucks, bridges, and overpasses. For example, a photograph taken of an entire parking lot from the roof of an adjacent building would be correctly called an elevated view photograph. An image of the same parking lot captured from a helicopter would be called an aerial photograph. These terms are used interchangeably at times to describe a photograph taken from an elevated viewpoint.

Fig. 9.1.1 is one of two Bell 429 Global Ranger helicopters operated by the Fairfax County, Virginia Police Department. Helicopters are a common platform for aerial photography due to the aircraft's stability, maneuverability, and their availability to photographers.

Many times, having an image from a higher point of view than is normal can be extremely helpful. These images can supplement your natural perspective images in several situations. Aerial and elevated view photos can be a great addition to your normal crime scene photography because higher views of the general area can show interrelationships between different locations much more effectively. Having a jury view the entire scene can make complex explanations of building relationships and traveled paths much easier to understand.

Fig. 9.1.2 shows such an example. Having completed one burglary in a shorter time than expected, the suspect decided to try another burglary in the same apartment complex. A confrontation with the second resident ended with that resident being stabbed to death. A very bloody suspect ran from the victim's apartment to his own apartment nearby. A police canine tracked the suspect's trail over the route indicated in the photograph. Such an aerial photograph can make it easier to explain all these relationships to the court.

Aerial or elevated view pictures can also act to summarize the story already told in chapters by photographs taken from eye level. A house fire provides an excellent example of this concept. Crime scene pictures from eye level will show various parts of the crime scene in piecemeal, but the aerial photograph provides a quick synopsis of the overall scene. Do you think the story can be summarized by reviewing the single aerial photograph (Fig. 9.1.3)?

The Marine Corps Marathon once ran through the streets of Arlington County, Virginia, and Washington, DC. As part of the planning for this event, aerial photographs were taken of the race route. With these aerial views of the entire race route, it was much easier to plan which streets had to be closed, where water stations were to be located, and where first aid stations would be set up.



FIGURE 9.1.1
One of two Bell 429 Global Ranger helicopters operated by the Fairfax County, Virginia Police Department. Helicopters are a common platform for aerial photography due to the aircraft's stability, maneuverability, and their availability to photographers.
Courtesy of Photographic Services Manager, Keith Dobuler, Fairfax County Police Department, VA.

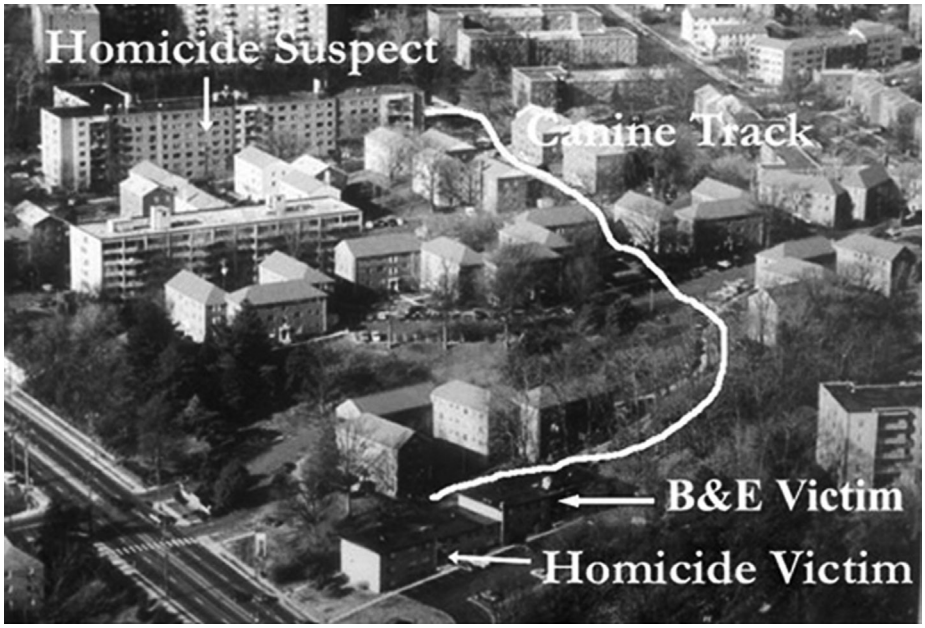


FIGURE 9.1.2
Homicide aerial photograph: canine track from victim's apartment to suspect's apartment.
Courtesy of the Arlington County Police Department, VA.



FIGURE 9.1.3
A fatal house fire with the victim found on the second floor.
Courtesy of Photographic Services Manager, Keith Dobuler, Fairfax County Police Department, VA.

If an arrest warrant or search warrant will be served at a location with a high potential for armed resistance or suspect flight, aerial photographs can assist with the planning of the police action. Possible entry and exit routes can be ascertained and blocked, and the best approaches for law enforcement personnel can be determined.

Look around the scene in question. What is the highest structure in the immediate vicinity? Consider using that structure as a platform for photographing the area of interest. When these structures will be insufficient for your purposes, aircraft can be considered. Many larger law enforcement agencies have access to aircraft used for a variety of situations: search and rescue, emergency movement of the critically ill or injured, transportation of dignitaries, and surveillance and aerial photography for law enforcement.

Fig. 9.1.4 shows a balcony and rooftop view of a crime scene and accident scene. Fig. 9.1.5 shows two aerial views of the area around the Falls Church, Virginia, Home Depot where DC area snipers, John Allen Muhammad and John Lee Malvo, shot and killed Linda Franklin. Linda Franklin was one of ten killed and four wounded by the snipers in 2002.

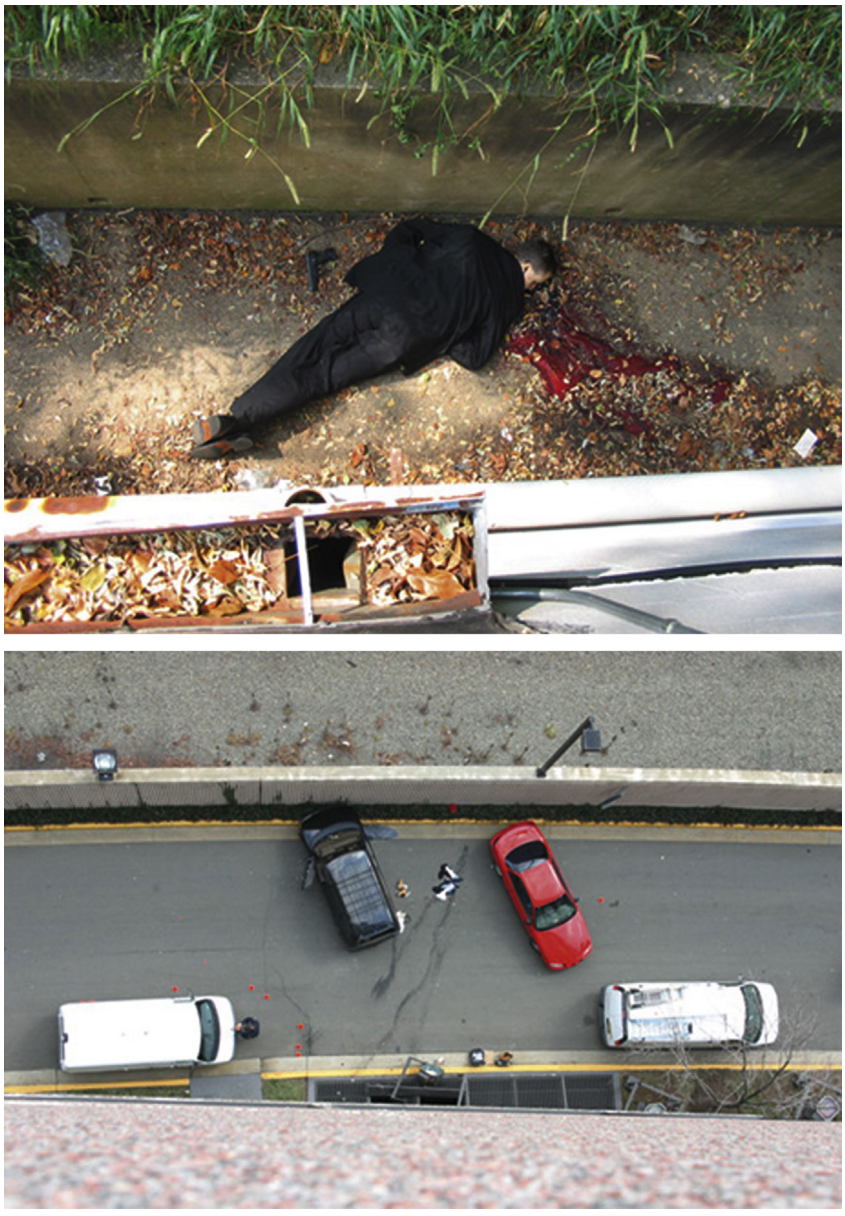


FIGURE 9.1.4
Balcony and rooftop views.
Courtesy of the Arlington County Police Department, VA.



FIGURE 9.1.5
One of the DC area's sniper shooting sites.
Courtesy of Photographic Services Manager Keith Dobuler, Fairfax County Police Department, VA.



FIGURE 9.1.6
Accident scene: from the ground, and an aerial view.
Courtesy of Arlington County Police Department, VA, and Pictometry International Corp., Rochester, NY.



FIGURE 9.1.7
Pentagon, just before the attack on September 11, 2001, and 3 days later.
Courtesy of the Arlington County Police Department, VA, and Pictometry International Corp., Rochester, NY.

Another possibility for obtaining aerial photographs is that many jurisdictions survey their land areas with traditional maps and sometimes with aerial views purchased from professional aerial photographers. These aerial views help with locating utility lines and their access, zoning issues, and construction planning. Local law enforcement also has access to these views.

Fig. 9.1.6 shows two views of an accident scene, one from the ground and one from an aerial view of the same area. The aerial view was provided by Pictometry International Corporation, which provides aerial views of all of Arlington County, Virginia, to all county agencies.

Fig. 9.1.7 shows three views of the Pentagon. The first is just before the September 11, 2001, attack, provided by Pictometry International Corporation. Superimposed on this image is a red arrow depicting the flight path of American Airlines Flight # 77. The middle image was taken on 9/11. The right image was taken 3 days after the terrorist attack.

Many readers may be familiar with Google Earth (http://www.earth.google.com). It provides satellite views of most populated areas of the world. It is fun to find your own residence photographed from space. But whose car is that parked in your driveway? Images captured by Google Earth may be used for general intelligence gathering, but it is unknown how long ago these images were taken. Buildings and landscape change, so these images cannot be used in court proceedings or as official documentation of a crime scene.

The military has made the use of UAVs commonplace in Afghanistan and in Iraq, and the use of UAVs has begun to filter down to local law enforcement agencies. Several agencies, including the Los Angeles County Sheriff's Department, are testing UAVs for their practicality in the field, which can include highly populated areas. With the cost of UAVs in the neighborhood of $30,000, they make very economical alternatives to the cost and maintenance of regular aircraft. It is easy to predict that the use of UAVs by law enforcement agencies will grow tremendously in the near future, as the price of this technology continues to drop.

DEVELOPING AN EFFECTIVE WORKING RELATIONSHIP

On many occasions, capturing aerial and elevated view photographs requires special equipment, or access to locations that necessitates outside assistance. Establishing a sound working relationship with an aviation unit, fire and rescue personnel, property owner, or other persons who hold interest in the photographic process is important. Effectively conveying your photographic needs and priorities to these entities and obtaining consent, will go a long way in fostering a professional working relationship.

When working with an air crew, conduct a preflight briefing to discuss the area to be photographed, the photographic goals, and the capabilities of the aircraft. Be mindful that situations out of the photographer's control, such as restricted airspace or the management of in-flight aircraft by air traffic control, may hamper the photography mission. While airborne, be clear and concise when communicating with the aircrew to convey the positioning of the aircraft desired to capture the best image. The goal is to capture the highest quality photographs that best document the area of focus.

You may think you know the area to be photographed very well, but how many times have you viewed this area from above? It is easy to get "lost" when viewing the scene from a plane or helicopter. Make sure you have a good map and have some obvious fixed features that you can see easily from above to ensure a proper orientation.

LIGHTING DURING AERIAL PHOTOGRAPHY

The majority of aerial and elevated view photographs will be taken using daylight as the primary light source. If the weather is clear, the angle and position of the sun must be taken into account because shadows can obscure details and important evidence on the scene. If possible, capturing images with the sun high in the sky will reduce the number of shadows present. At this position, long oblique shadows will be minimized, if not totally eliminated. In general terms, between 10 am and 2 pm is the best time of day for photographing if scheduling allows. If you are lucky, a bright overcast day is ideal for aerial and elevated view photography due to even lighting and no shadows.

Fig. 9.1.8 represents an image taken under bright overcast conditions. Note the even lighting and the lack of harsh shadows. Fig. 9.1.9 captured on a partly cloudy day, shows sunny conditions along the left and bottom of the photograph and cloudy conditions on the top right. Also, notice the shadows produced by the trees.

Being responsible for your overall image means preventing the shadow of the plane, helicopter from being captured when you snap the shutter. Sometimes, based on the availability of aircraft or resources, aerial and elevated view photos will be taken in less than ideal conditions. Do the best you can with what you have!



FIGURE 9.1.8
McConnell Public Safety and Transportation Operations Center (MPSTOC) Fairfax, Virginia.
Courtesy of Photographic Services Manager Keith Dobuler, Fairfax County Police Department, VA.



FIGURE 9.1.9
Sunny and cloudy conditions in the same photograph.
Courtesy of Photographic Services Manager Keith Dobuler, Fairfax County Police Department, VA.

CAMERA CONTROLS FOR AERIAL AND ELEVATED VIEW PHOTOGRAPHY

Motion Control

The vibration and motion of the aircraft are the most important elements to consider and the main contributor to poor image quality during aerial photography. Vibration is transmitted through the aircraft frame, through the body of the photographer, and then the lens of the camera. Forward and lateral motions of the aircraft are similar to moving objects when photographing at ground level. The primary concern with most aerial photography is to eliminate the blur associated with motion and vibration.

- The motion of the aircraft: Even a helicopter is moving at all times. It is virtually impossible to have the aircraft completely motionless. Besides moving forward and backward, the aircraft is constantly moving upward and downward, either intentionally, or because of updrafts or downdrafts.
- The motion of the camera: The primary concern is with the vibration of the airframe itself being transmitted to the photographer and camera. To minimize this vibration, avoid contact with hard surfaces within the aircraft. Do not brace yourself on any part of the aircraft. Your only contact with the aircraft should be where you sit on the padded seat (avoid the seat frame and arm rail) and where you come into contact with the seat belt or harness system used in some situations.
- The solution to all these motion concerns is to use a minimum of 1/500 second shutter speed; 1/1000 is better, if it can be obtained while maintaining proper exposures. This deserves to be a Rule of Thumb.

RULE OF THUMB 9.7

The shutter speed for aerial photography should be at least 1/500 second, if not 1/1000 second.

Early in this author's law enforcement career, the best view of an accident scene was from a nearby bridge. Feeling steady on the bridge, this author mounted the camera on a tripod and used a 1/60 shutter speed. All the photographs from the bridge came back blurred. That was when this author first learned that bridges are designed to be flexible, and the bridge was moving during all the photographs. Learn by this mistake: consider every bridge to be moving, and use a faster shutter speed to freeze this motion.

Focus

For the vast majority of aerial and elevated view photographs, the focus will be infinity. The depth of field will not be a factor from the altitude or elevation the photographs are captured from. Maintaining the lens at a wider aperture will allow the use of a faster shutter speed which is a must for aerial pictures. Better yet, use an aperture two stops in from the widest aperture: the critical sharpness range of f/stops. Two stops in from the widest aperture puts the camera into the "sweet spot" of the lens. Recall the previous discussion on diffraction. This will ensure both the ground level and the tops of buildings are in focus.

Lenses

It is best to use a zoom lens to allow quick variation in focal lengths. Try to avoid lens changes during the shoot, unless you have an assistant handing you equipment, which is also strapped down. Prime wide-angle and super-telephoto lenses are not appropriate tools from most aircraft heights.

You will find, however, that short telephoto lenses are particularly useful when taking aerial photographs. But, just as handholding a 100 mm lens on the ground requires a faster shutter speed, when you are taking aerial photographs with a 100 mm lens, a faster shutter speed is necessary. If 1/500 to 1/1000 shutter speed is recommended with a 50 mm lens in an aerial photography situation, consider 1/1000 and 1/2000 as the optimal shutter speeds with a 100 mm lens in an aerial situation. This would also be an excellent time to use a lens with vibration reduction or image stabilization capability.

Filters

Citizens of Los Angeles, California, and Phoenix, Arizona, know about particulate contaminants in the air, but most of us have not had much experience with such air pollution. As the distance between the camera and the subject being photographed lengthens, the contaminants in the air can begin to degrade the resulting image. For most photography, this is insignificant. When you are doing aerial photography, it begins to matter.

Prior to digital cameras, film acted as the primary method of capturing images. Photographers often used filters to improve the quality of aerial pictures taken at a high altitude or long distances. UV and haze filters were widely marketed for the film medium. Today, the majority of crime scenes are captured with a digital camera and the use of filters does not improve image quality. Most modern digital cameras employ a UV filter over the sensor, so the use of a UV filter on the lens itself has no benefit and can act to degrade the picture quality. Know the capabilities of your camera before using a filter in an attempt to improve image quality. You may only have one chance to capture aerial or elevated view photographs, so make sure you camera is set up in the proper fashion with the proper equipment.

Composition

As mentioned previously, avoid having your own shadow in the photo (plane or helicopter). Also, avoid aircraft wings or other aircraft components being in the field of view. This may require the pilot to roll the aircraft over a bit so that you can view straight down. Fig. 9.1.10 is a photograph captured as a helicopter is rolling to the right. Notice how the photograph appears to be captured looking straight down instead of from an angle. The location of interest in this image is the vehicle with trailer located directly below. The imaging sensor of the camera is nearly parallel to the ground allowing for an image more accurate for measurements and interpretation than one taken at an oblique angle.

Aerial photographs taken in a plane or helicopter will most likely be taken though the aircraft window. Subsequently, reflections and glare are of great concern. Ensure the aircraft windows are cleaned prior to take off to limit the chance of poor quality photographs. The use of a wide aperture for aerial photographs will limit the reflection and glare from the windows. Additionally, using manual focus on the camera instead of the auto-focus decreases the chance of the camera making a mistake.



FIGURE 9.1.10
Perpendicular view, or vertical view of a parking lot.
Courtesy of Photographic Services Manager Keith Dobuler, Fairfax County Police Department, VA.



FIGURE 9.1.11
Photographer in the open door of the helicopter.
Courtesy of Fairfax County Police Department Crime Scene Section, VA.

Another option is capturing the photographs with a door or window open in the aircraft (if equipped). This option also increases the risk involved and will require an extensive discussion with the air crew. Utilizing a harness when an aircraft door or window is open is a requirement. Additionally, a crew member should be positioned at your side to ensure safe operations. Fig. 9.1.11 shows the harnessed photographer in the open doorway.

ISO Speeds

One huge benefit of digital imaging is the ability to change ISOs at any point. If you are one of the few still using a 35 mm camera, changing film while in midair is extremely difficult.

On a normal sunny day, ISO 100 is recommended. However, it is also normally recommended to use a shutter speed of 1/60 of a second. Try setting the camera to 100 ISO and 1/1000 shutter speed and take a meter reading of a sunny area. If the resulting aperture is close to two stops from the widest aperture of the lens, then 100 ISO can be used. If not, try the same exposure readings with ISO 200 and then ISO 400. Remember, aerial photographs are frequently enlarged, and slower ISOs will enable bigger enlargements without apparent digital noise.

Exposure

The f/16 sunny day rule works during aerial photographs also. An f/16 and 1/125 (a bright sunny day with crisp shadows) used with ISO 100 can be converted to f/5.6 and 1/1000 because of reciprocity.

Also recall the old Rules of Thumb: It is better to overexpose film and it is better to underexpose digital images if exposure errors are unavoidable. Doing brackets may be difficult while flying in circles around the scene of interest, but it sure beats having to make plans for a second aerial excursion because your first images were improperly exposed; with digital imaging comes the ability to instantly see your results.

SPOTLIGHT ON LAW ENFORCEMENT AVIATION, THE FAIRFAX COUNTY POLICE DEPARTMENT

The Fairfax County Police Helicopter Division provides tactical police aviation support, aeromedical evacuation, search and rescue, and other specialized air support as needed within Fairfax County and the National Capital Region to enhance public safety and welfare. A crew of two cross-trained police officers/flight paramedics and a pilot are available 24 h a day 365 days a year to serve the community and protect life and property. Fig. 9.1.12 is an image of helicopter division members and the two Bell 429 helicopters they buzz the sky from.

An aviation unit is an excellent resource not only for crime scene photography, but also for finding missing children, quickly transporting the sick or injured, decreasing the danger of high-speed pursuits, and providing officers on the ground with eyes in the sky. Advanced tools on law enforcement helicopters, such as that on Fairfax 1 (the call sign of the Fairfax County Police Helicopter), include state of the art camera systems with infrared technology, a search light, sophisticated communications equipment, and mapping systems. These tools are at your disposal as a photographer and may prove beneficial to capturing the best crime scene photos possible.



FIGURE 9.1.12
The Fairfax County Police Helicopter Division and their two Bell 429 helicopters.
Courtesy of Photographic Services Manager Keith Dobuler, Fairfax County Police Department, VA.



FIGURE 9.1.13
IR imaging making fleeing subjects look white.
Courtesy of Fairfax County Police Helicopter Division, VA.

Figs. 9.1.13 and 9.1.14 are images of fleeing subjects during the night. The infrared imaging capability of the two Fairfax County Police Helicopters make subjects on the ground appear white from their body heat. The top image has three subjects running into a residential area and the bottom image has a subject running from his disabled vehicle. The heat generated from a nonrotating tire has also left a white trail.

Fairfax County, Virginia, hosted the 2015 World Police and Fire Games. This is the second largest athletic event in the world, next to the Olympics. 12,000 competitors from around 70 countries participated. It is understandable that the Fairfax County Police Helicopter Division would be involved in various ways. Fig. 9.1.15 shows RFK Stadium, Washington, DC, at the beginning of the opening ceremony, taken from Fairfax 1 (the call sign of the Fairfax County Police Helicopter) with Fig. 9.1.16 capturing the event from inside the arena.

Safety Concerns

For most crime scenes, capturing photographs from an elevated position or through the window of an aircraft will suffice. In an aircraft, even with the doors and windows closed, you should still be securely seat belted in. Unexpected turns or turbulence can throw you around the interior of the aircraft especially if you are looking through a lens and not expecting it.



FIGURE 9.1.14
IR imaging making a fleeing subject look white.
Courtesy of Fairfax County Police Department Helicopter Division, VA.

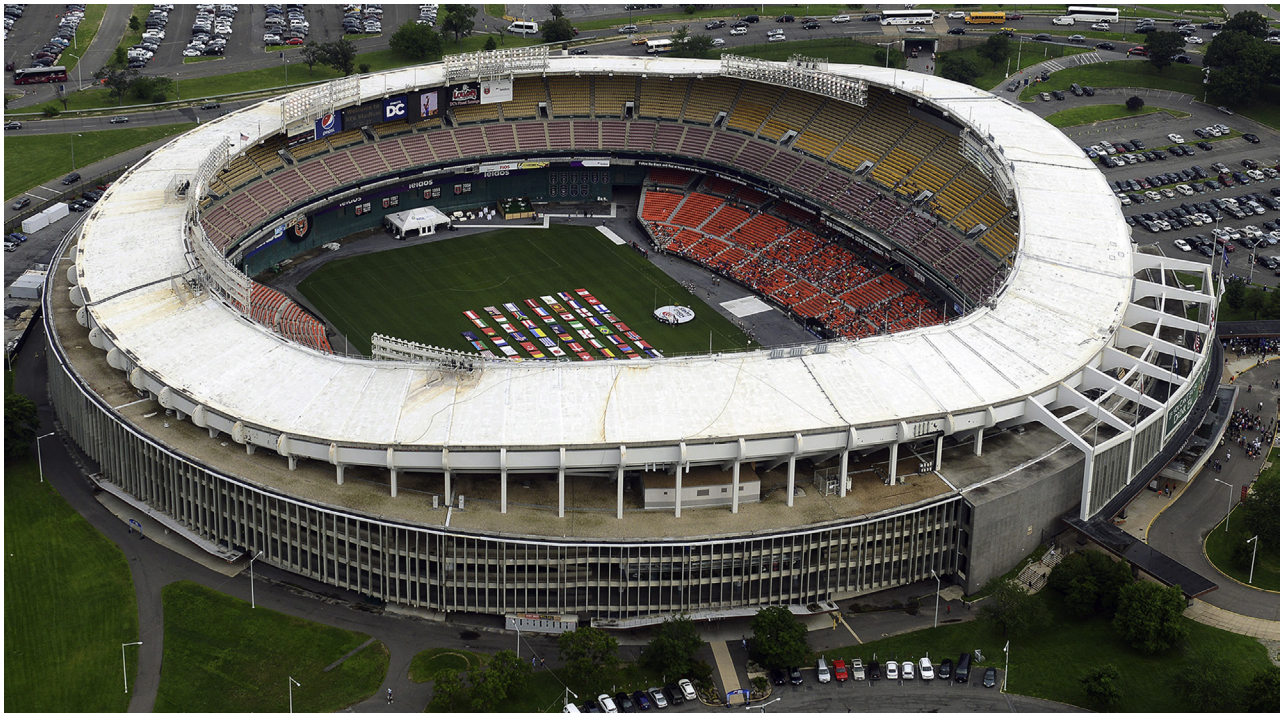


FIGURE 9.1.15
RFK Stadium, site of the 2015 World Police and Fire Games, hosted by Fairfax County, VA.
Courtesy of Photographic Services Manager Keith Dobuler, Fairfax County Police Department, VA.

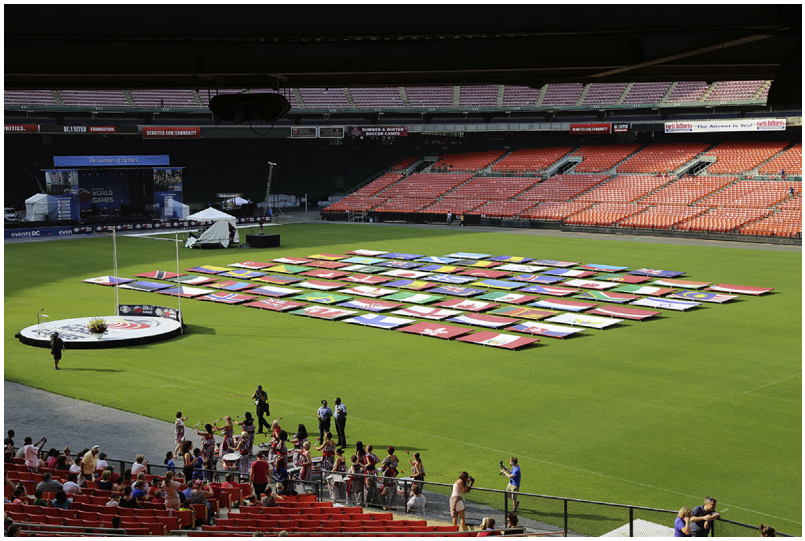


FIGURE 9.1.16
Flags of the participating nations.
Courtesy of Fairfax County, Virginia, 2015 World Police & Fire Games, http://fairfax2015.com/.

For situations that call for aerial photographs through an open aircraft door or window, safety is a concern more important than getting the images justifying the trip. It is certainly a rush to be in a helicopter, sitting next to a large gaping hole where the door had been before it was removed. Now, when the pilot tilts the "copter" a bit to give you a good view of the ground, the adrenaline begins pumping. The amount of air swooshing around you is difficult to imagine on the ground. When you are advised to strap everything down, the reason is that not only will gravity pull loose things down, but the air flow will pull things out of the aircraft laterally.

Initially, you may just think about the loss of expensive equipment. After just a second, though, you should also think about what happens when this expensive equipment hits the ground. Actually, hitting the ground would be a good thing. Imagine if it hits a moving vehicle or person. Michael J. Brooks, previously an FBI Senior Instructor of Scientific and Technical Photography, lectured on this same topic and mentioned yet another concern. A jacket, a backpack, or camera equipment can get swept out of a helicopter and get sucked up into the tail rotors. Do not dwell on this thought. Just ensure everything within the aircraft is strapped down. This includes looking out for #1! Make sure you are securely tethered to the aircraft with a member of the flight crew at your side to ensure your safety. You have to be alive to brag about your great aerial images!

SUMMARY

Aerial photography presents many challenges to successful photography. It is important to be aware of the potential problems that may arise and the methods that have been developed to ensure a satisfactory result. This chapter indicated the factors that must be dealt with and the problems that must be overcome when doing aerial photography.

DISCUSSION QUESTIONS

1. What are the main lighting concerns related to aerial photography?
2. How is all the motion related to aerial photography controlled?
3. Indicate some safety concerns related to aerial photography.

Further Reading

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SUBCHAPTER 9.2

Autopsy Photography

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Medical examiners and coroner offices have a need for photo documentation of bodies, injuries, disease, and accompanying materials, such as clothing and weapons. Offices vary widely in how they accomplish this. Many forensic pathologists take their own photographs or perhaps augment the photographs of the staff. Some offices have full time professional photographers, while other offices have various staff, such as autopsy assistants or medicolegal death investigators, perform this duty. Some offices rely on law enforcement agencies to take the photographs. Furthermore, some law enforcement agencies may take their own set of photographs in addition to the official photographs of the medical examiner or coroner offices, although many offices will not permit such a practice. Regardless, it would seem that readers of this book may have occasion to take autopsy photographs, and hence this chapter is now included in this textbook. We believe that whoever takes these photographs should be knowledgeable of photography and cognizant of the basic concepts that we present in the following paragraphs.

There are two unique aspects of autopsy photography that distinguish it from other forms of evidence documentation. First, as in other fields of forensics, the autopsy photograph serves as documentation of physical evidence. However, unlike many other forms of physical evidence, the body is likely never to be available for examination again after final disposition. Even if the body is available, it is never going to be in the same condition as it was before the autopsy. In this sense, autopsy photographs *become* the physical evidence; they are usually the main material relied upon for review, examination, and diagnosis by the primary pathologist, his or her peers, and additional experts. As such, they must be true and accurate, scaled substitutes for the body—not simply documentation of the evidence.

Additionally, images of the decedent are much more humanity- and emotion-laden than other forms of physical evidence, such as a cartridge casing, and have a greater impact on families, juries, media, and the public. In order to adequately document findings of evidentiary value, the collection of autopsy photographs will necessarily include images of both internal and external surfaces in vivid and unaltered detail. However, there is an expectation that the photographs will be emotionally neutral and respectful of the decedent and family. Thus the autopsy photographer is uniquely burdened to provide a true and accurate representation of disease and injuries identified by an invasive procedure, but do so in a respectful, nonprejudicial, and nongratuitous manner.

This section strives to provide any autopsy photographer—be it the performing pathologist, pathology assistant, crime scene technician, police officer, or dedicated photographer, with the foundational knowledge of autopsy photography standards, common techniques, tips for special procedures, and advice resulting from practice by the authors. Care taken during the autopsy using standard photography techniques discussed elsewhere in this book, and principles of autopsy photography discussed in the following paragraphs, will provide the reader with the necessary knowledge to produce quality photographs for use in daily autopsy practice.

THE AUTOPSY PROCEDURE

An understanding of the process will help the photographer recognize the pertinent positive and negative findings crucial for adequate documentation and to anticipate those points at which the anatomy will be irrevocably altered, and the photographic opportunity lost.

Although it is rarely portrayed as such in the popular media, the autopsy is indeed a medical procedure performed by a physician upon a patient to determine the cause and manner of death. Manipulation of the body in death, as in life, must occur in order for the physician to fully examine and diagnose the patient. The autopsy is a dynamic examination of both the external and internal aspects of the body in search of disease or injury which resulted in death. It begins with inspection of the external surfaces of the entire body in an organized fashion. This entails more than simply looking at the chest, abdomen and back, and includes details such as the eyes, the ears, the mouth, the genitals, and crevices of the body such as underneath nails, within the hair, within the armpits, between the toes, and in the crooks of the arms.

The procedure then turns to the inside of the body by reflection of the skin of the chest and abdomen to reveal the ribs of the chest, and the organs of the abdomen. Upon removal of the chest plate, all the organs of the chest and abdomen are visualized, inspected, and removed for further examination. After the organs are removed, the posterior aspects of the torso, particularly the ribs, spine, and pelvis are inspected. If not concurrent with the assistance of a technician, the examination of the head will then begin with reflection of the scalp, followed by removal of the cranium, and the removal of the brain. The sensitive structures of the neck are often the last to be examined. The organs themselves are further sectioned and examined for injury or disease.

This brief description makes obvious that multiple points of photographic interest arise during the autopsy. As each autopsy differs by virtue of unique disease processes and injury patterns, the number and nature of these points of interest will vary from case to case. If the photographer is not the pathologist, he or she may not recognize subtle findings and will likely be instructed by the pathologist on what to photograph and when. However, the astute photographer will note the diagrams, templates, and charts the pathologist relies on for documentation and dictation; these tools often include abbreviated designations (such as "SS" for "surgical scar"; "NPT" for "nonprofessional tattoo"), dedicated regions, as well as frank descriptions, which will inform the photographer which details the pathologist anticipates to be important in a standard autopsy.

DECEDENT DIGNITY

The autopsy is an invasive medical procedure and photography is necessary to capture the graphic detail of the procedure in order to accurately document it. However, there is nothing intrinsic to the autopsy procedure which suspends the right of the patient to a dignified examination, or induces any component of the autopsy, including photographs, to violate that dignity. The quality of photographs taken at autopsy reflects the care of the photographer to maintain the decedent's dignity, even on the background of the potentially disturbing nature. By far, careful composition is the simplest method to ensure a dignified photograph. Of course, initial photographs must include the unaltered scene, as discussed elsewhere in this book. However, preservation of evidence and composition are not mutually exclusive concepts. When the area itself cannot be altered, the photograph can be framed so that items not intrinsic to the autopsy (eg, debris left by EMS, people in the background) are excluded. Once the original findings have been documented to the satisfaction of law enforcement and the pathologist, cleanliness will be the greatest aid to the photographer in any autopsy.

Bloody gloves, tools, or debris of the autopsy should never be part of the autopsy photograph. Given the time and energy devoted to obtaining autopsy photographs, there is no logic in sabotaging the effort by failing to remove an offensive object. Likewise, the autopsy suite is replete with water and cleaning materials such that blood or other fluids can easily be cleaned from the area in view. If instrumentation is required to demonstrate the pertinent findings, such instruments should be clean and neatly placed. Gloved hands, too, should be clean if they must be part of the photograph. If the photographer is not in a position to prepare the field otherwise, tools such as towels and backgrounds can cover unwanted areas within the image frame, or to obscure people, objects, or other regions of the autopsy suite.

The images themselves should be treated with the consideration given to other physical evidence. Access to images should be controlled by policy and privacy controls, such that they cannot be altered, destroyed, or distributed. One staff member, or a limited number of staff members, should be charged with the filing, labeling, and storing of photographs, as well as creation of policies regarding autopsy photograph retention. Digital images should be duplicated either in hard copy (prints or CDs), or be duplicated electronically in an outside facility. Although use of de-identified photographs for educational purposes are generally accepted, the distribution or retention of photographs should be controlled by policy in accordance with individual state laws. No image should ever be utilized for personal use, and access to any case photographs should be limited and controlled.

IDENTIFICATION

One of the main functions of the autopsy photograph is to provide visual identification of the decedent. The National Association of Medical Examiners (NAME) accreditation guidelines, as well as NAME Autopsy Forensic Performance Standards, state that at least one photograph should be taken of the face for the purposes of visually identifying the individual (NAME I&A Checklist F.6.i,; NAME Autopsy Standards C7.2, 2015). This photograph, as against the scene photograph, should be done when the face is clean, recognizable, and presentable to the family or a jury. This photograph is often not the first photograph obtained, as the nature of evidentiary photography dictates documentation of the body and associated findings "as is" before cleaning. However, at some point, an identification photograph should be part of the protocol.

There is wide variation among offices regarding the identification photograph. Although most take at least one *en face* (head on) image some offices prefer to include profile images of the decedent from both the left and right sides. Reasons for these preferences include claims that profile images contain more characteristic features for identification, while others state profile images are less disturbing to the family.

Each photograph should include a unique identifying number assigned to that case. It is common practice to write or attach this unique identifying number on a disposable scale used throughout the case. This combination satisfies the requirement per NAME (NAME I&A Checklist F.6.b) and provides continuous identification of all the photographs throughout the autopsy. If the photographer is assigned to more than one autopsy at a given time, it becomes of paramount importance that the unique identifying number be correctly assigned in the photograph. Close-up images of the body are often indistinguishable, and such photographs sorted by identifying number alone could be disastrous if the identifier is transferred to another case. At the very least, the identifying number should remain close to the decedent or autopsy table. If possible, a colored font or mark can be attributed to individual stations or cases. Likewise, separate, uniquely identified secure digital (SD) cards routinely kept near specific autopsy stations may reduce error. If budgets allow, multiple cameras separated in the autopsy suite by station can also be helpful.

The face is not always a reliable means of identification. Postmortem change, injury, and disease can obscure individual facial characteristics. In some cases, the image is too emotionally charged for the family to view. For these reasons, scars, tattoos, and birthmarks are thoroughly documented at autopsy. Photographs of these characteristic findings can sometimes be used to assist in identification in lieu of the face photograph; however, the face photograph should still be taken. Such images should be taken using the three-level photographs described in the following section. Variations of anatomic structures such as bifurcation of a rib, or unique anatomy (eg, situs inversus) may also assist in identification, and as such should have photographic documentation as the autopsy proceeds. Surgical implants used for identification should be photographed outside of the body if they can be removed, in lighting or at angles which will allow for visualization of the unique serial number. The exception to this includes plates in the skull or artificial hip joints which are difficult to remove, and staples on organs or wires in the chest, which would lose characteristic placements and configurations once they were removed from the body.

Finally, of some success to one author (Rogalska) has been imaging of fingerprints. In cases of partial or full mummification, the desiccated fingertips may be too irregular for printing by conventional methods. Photographs of the fingerprints close enough to visualize characteristic ridge details, such as those in Fig. 9.2.1, were used successfully to compare known fingerprints. Additionally, "degloved" fingerprints too delicate to print, placed between two glass slides and photographed, have also yielded ridge detail sufficient for identification purposes. Indeed, any visual characteristic utilized for the purposes of identification may be amenable to photographic imaging. Even if these images do not provide positive identification, they document and preserve the detailed finding, and may be used to confirm additional circumstantial identification.

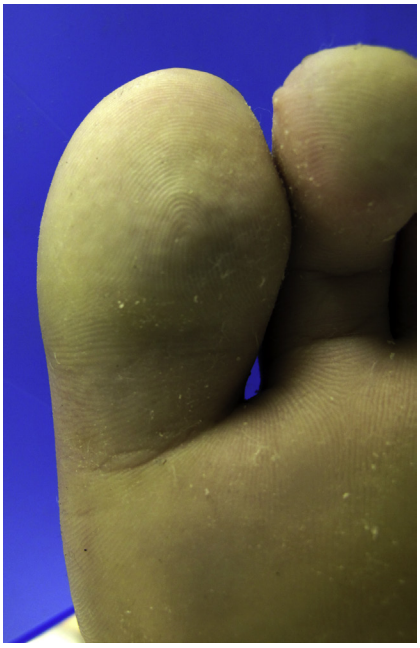


FIGURE 9.2.1
Fine detail of dermal ridges can be captured for identification purposes.

PHOTOGRAPHING THE AUTOPSY

The autopsy has both external and internal components, and both should be captured photographically in sequence as they progress. In general, the autopsy relies on three levels of photographs of the body throughout the various stages. The first is the overall or distant photograph which attempts to capture as much of the body as possible, usually in overlapping panels at overhead or side angles. These photographs demonstrate that the findings are indeed of the same decedent, and allow the relationships between findings to be visualized as a whole. The fine details of a significant finding are then documented in as close a range as possible which will allow the entire injury and appropriate scale to be visualized in clear focus. The photographs between these two, the intermediate photographs, bridge the limitations of the other two distances, and can provide relationships of the injuries to related anatomy or adjacent injuries.

Autopsy suites and morgues vary greatly in architecture and interior design. Regardless, there should be adequate lighting for photography—in fact, it is a NAME standard (NAME I&A Checklist C.3.e). Some autopsy suites have special areas for photography, but in most cases photography is accomplished at the autopsy dissection table or gurney. A surgeon's light might be attached to the ceiling. Perhaps the best lighting is the bright diffuse light provided by tall ceilings with dense lighting. The color of the lighting is also important. Fluorescent lights in particular vary greatly; they should be daylight bulbs which mimic sunlight—high Color Rendering Index (CRI) with more red tones and less green. Regardless, it is likely that the photographer will not have optimal lighting and will achieve the best results with a flash even in an otherwise well lit room. Also, the autopsy photographer will want to have a kick ladder available as it is often necessary to take pictures from above the body and at some distance.

The use of a scale in each autopsy photograph is required by NAME for close-ups (NAME I&A Checklist F.6.e) and major injuries (NAME Autopsy Standard E14.2, 2015). In addition to identification, the scale should allow for the 1:1 reproduction of an object or injury, which may be used to support documentation, refute interpretations, and allow for comparisons to determine potential sources of the injury. It is common practice to write or attach a unique identifying number on a disposable scale to be used throughout a given autopsy (Fig. 9.2.6). Regardless of the level of the image (overall, intermediate, or close), all photographs should have this visible scale of reference. Whenever possible, the scale should be adjacent to the pertinent finding being photographed, and should not obscure any portion of it. In those instances where the scale must obscure a portion of the finding, a photograph with the scale in a different position should be taken, such that the sum of the photographs allows full view of the entire area. Although no specific guidelines exist on the matter of scale placement, maintaining consistency in the placement of the scale will allow the future viewer to easily and quickly orient the photograph and findings, as described below.

An "L"-shaped macrophotography scale provided by the American Board of Forensic Odontology (ABFO No. 2) is often used in the field. It provides not only linear measurements in the *X* and *Y* axes, but also tilt correction and gray scale (Hyzer and Krauss, 1988). (Fig. 9.2.2) The ABFO scale is required by NAME guidelines for the photography of suspected or known bite marks (NAME I&A Checklist F.6.f). The presence of circles on the scale permits rectification of the image, but software is required to take optimal advantage of this feature. Regardless, multiple photographs at various planes perpendicular to the surface should be taken, in order to capture the true and accurate size, orientation, and configuration of the pertinent finding. Due to significant errors and deviations in commercially available scales, the validity of the scale should be confirmed before use or a National Institute of Standards and Technology (NIST)–traceable version should be purchased (Ferrucci et al., 2013).

Color scales are sometimes used by law enforcement, but are not typically encountered in the autopsy suite, and are not required by NAME. These scales can be useful for color balance, and to document subtle findings among diverse skin tones. In particular, a camera may automatically compensate for a prominent background color resulting in distorted tones—blue backgrounds make skin and bone appear yellow, while green backgrounds tend to make red tones more prominent and findings more "bloody" (Fig. 9.2.3). The reader is directed to other sections of this book for more detailed information on their use.

Overall Images

If office policy does not include photography of a sealed body bag before it is opened or its tag, then the process begins with photographs of the decedent in the body bag as received in the morgue. This step has three major purposes. First, it ensures adequate documentation of the procedure, including where all clothing, debris, injuries, and potential evidence is located before any manipulation of the body to allow corroboration of scene evidence and reports. This step also provides locations of clothing, jewelry, and medical devices which may create artifacts confusing to the pathologist later in the examination. Finally, the documentation of personal property and valuables visually documents the chain of custody of these items for the court, and for the families of the decedent.

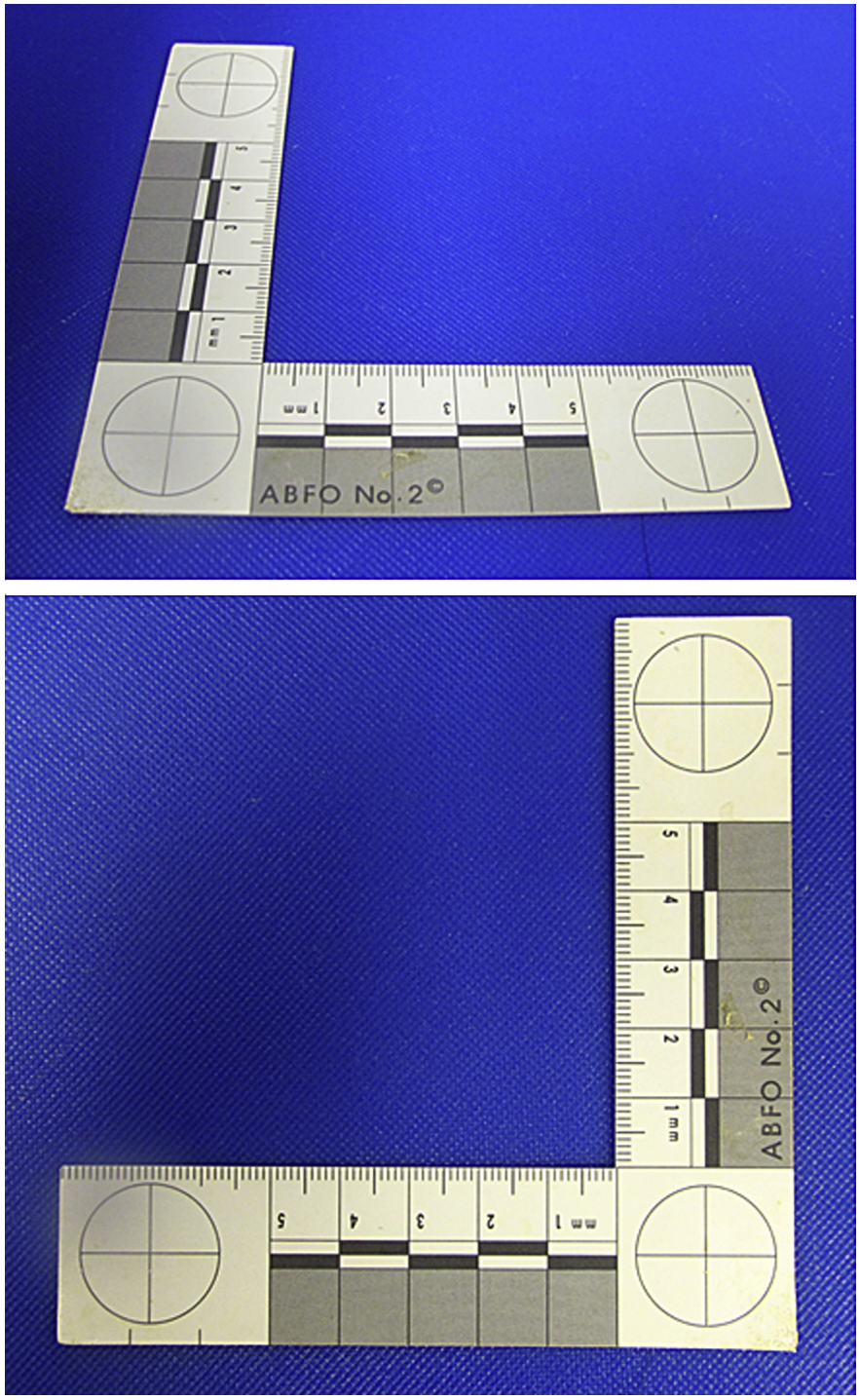


FIGURE 9.2.2
ABFO no. 2 scale.

"As is" photographs should be taken of the decedent, either upon opening of the body bag or when first placed on the table and before the body is unclothed and before an initial search for trace evidence. This is a NAME requirement (NAME I&A Checklist F.6.c). These photographs should include, at a minimum, a two or three panel overhead series to capture the entire body. If the body is twisted or turned, two to three panel side views are recommended. Jewelry and personal property, as well as evidence, should be photographed in place before being removed, and photographs at distant (orienting), intermediate, and close (detail) ranges should be obtained.

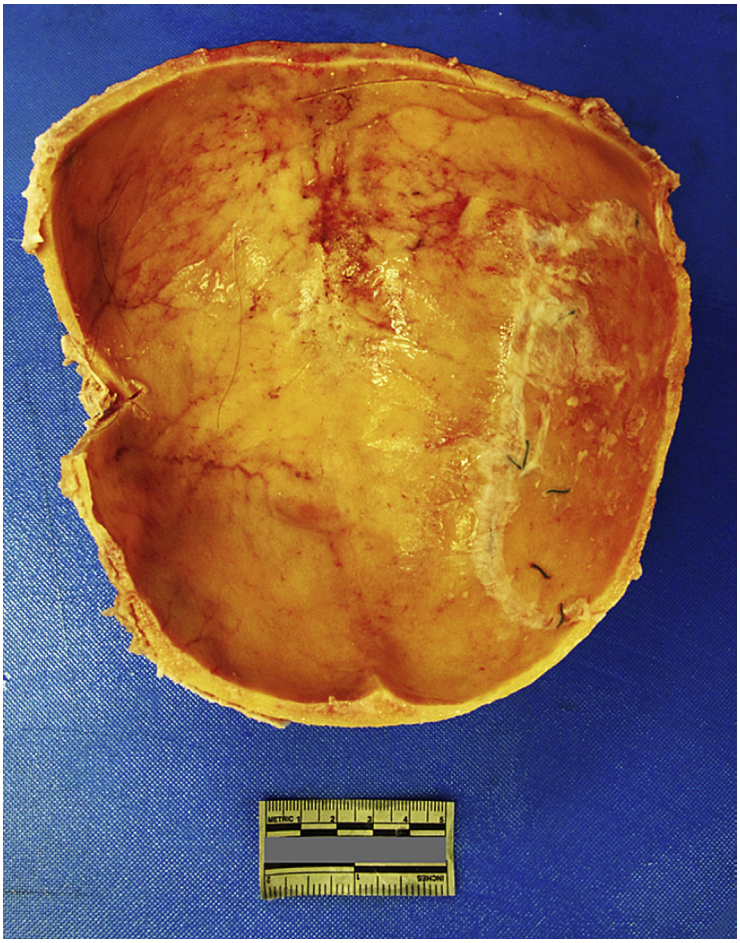


FIGURE 9.2.3
Photograph of the inside surface of the skull calvarium demonstrating that the prominent blue background gives the skull an exaggerated yellow appearance.

As clothing and personal items are removed, the body should again be photographed overall *before* the body is washed. Any injuries or significant findings should be photographed at intermediate and close ranges to provide detail which may be altered or lost with cleansing, such as gunpowder soot (Fig. 9.2.4). Although these initial photographs, particularly of injuries, will likely be considered too graphic for court purposes, these may be the only photographs documenting the state of the injuries as first seen by police, EMS, or Medicolegal Investigator; these may be the only corroborating evidence of descriptions made by first responders, which may differ from the final autopsy findings. Finally, they protect the pathologist from accusations of altering the injury, by providing graphic documentation of the artifact, such as clotted blood or dirt, which altered the appearance of the wound from first photograph to clean final close-up.

Overall views of the body also orient multiple injuries on the body anatomically in one or two photographs. These can be very useful in court as they quickly and easily demonstrate to the jury the number and location of injuries, without being detailed or graphic. Additional panel photographs of this nature are most useful in court when portions of the body not involved by injury, specifically the face and genitalia, are excluded from the frame of the photograph. If it is not possible to exclude such features, they can be covered with a folded surgical towel before the picture is taken ("modesty" towel). These small steps taken during the autopsy clearly demonstrate respect and dignity toward the decedent, and have significant impact on court admissibility, jury impact, and impact on the families who may be forced to see these pictures in the courtroom.

It should be noted that ladders or stools are invaluable tools for capturing the overall photograph. As in close-up photographs, the angle of the image should be perpendicular to the plane of the area photographed; this allows for accurate 1:1 scaling of the image. Single lens reflex cameras with lenses of large focal length often fail to focus if the camera is too close to the body. While shooting from the ground at anything less than a 90° angle can capture the entire body, the inherent distortion of length is an unacceptable consequence of this maneuver.



FIGURE 9.2.4
"As is" close-up photograph of gunpowder soot on the hand of a shooter, which would be lost after cleaning.

Close-Up Photographs

While the distant photographs demonstrate anatomic relationships of the body, the close-up photograph serves to record specific details without the distraction of other anatomic findings. The close-up photograph is of particular importance in cases of nonnatural death, where injury patterns may indicate the source of injury. NAME requires that photographs be taken of injuries unobstructed by blood, foreign matter, or clothing (NAME Autopsy Standards, E.14.1). Sometimes, close-up photographs are the only means of capturing the minute detail of small anatomic structures, such as the pinpoint hemorrhages in a child's eye.

There are no specific criteria defining close range. But generally speaking, the range should be such that the pertinent findings and associated details are centered in the frame of the photograph, including a unique identifying number and scale, while unrelated findings and anatomic landmarks are specifically excluded. Pertinent details must be in focus and appropriately lit to allow visualization of specific markings, patterns, or associated pathology which correlate to the documentation of the autopsy report, and could corroborate or refute correlation with a causative agent, such as a weapon.

In most cases of injury, accurate and detailed documentation will require multiple photographs of the same injury throughout the course of the examination. At a minimum, photographs of the unaltered injury, followed by images of the cleaned injury should be available. However, most will require sequential documentation of the area as it is cleared of any obscuring artifact such as hair and clotted blood, and as cleansing reveals and potentially destroys, additional features, such as gunpowder soot (Fig. 9.2.5). Likewise, serial photographs should document any reconstruction of a wound, such as approximated stab wound edges. As in all autopsy photographs, a unique identifying number and appropriate scale should be used, and the camera oriented perpendicular to the plane of the object being photographed to allow for 1:1 representation. Additionally, wounds may be arbitrarily designated by adhesive letters and numbers, and should be photographed both with and without the designator, to document that no portion of the image is being obscured.

The pitfall of the close-up photograph is that the spatial orientation is lost by virtue of excluding unrelated anatomy. Intermediate distance photographs, described below, are used to ameliorate this problem. In fact, NAME requires orientation photographs of close-up photographs (NAME I&A Checklist F.6.d). Maintaining consistency in placing the scale can also be helpful, particularly when oriented in the standard anatomic position. This will also maintain consistency in descriptions of significant findings in the autopsy report as 12 o'clock will always mean the top of the head, 3 o'clock will always mean to the decedent's left, and 6 o'clock will always indicate the bottom of the foot. Regardless, precision in close-up photographs may require sophistication (Evans et al., 2014).

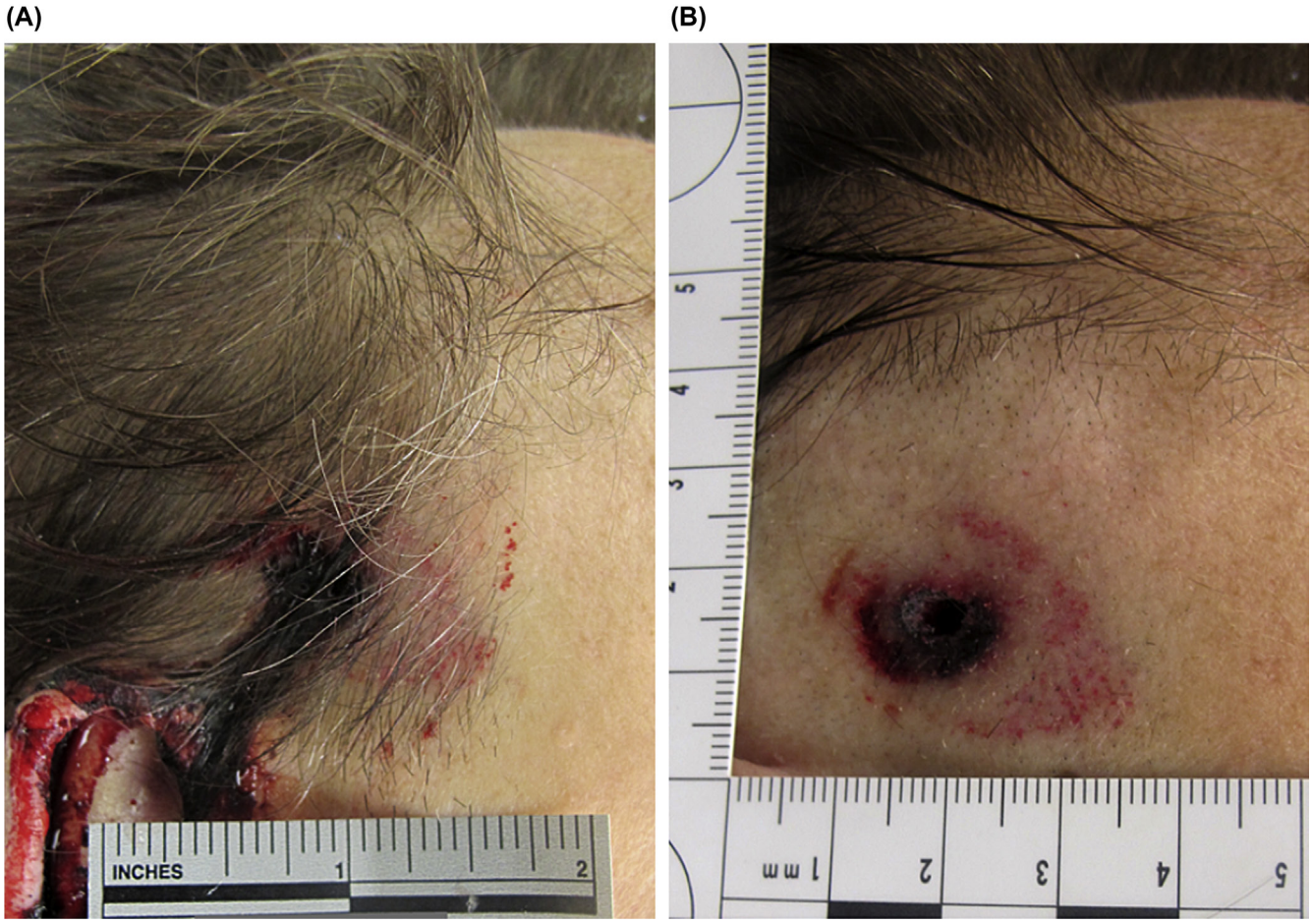


FIGURE 9.2.5
(A) "As is" close-up of a gunshot wound of the head; although obscured by blood and hair, soot is still visible. (B) Muzzle imprint visible after removal of the hair.

Intermediate Photographs

With serial photographs of both long-distance and close-range photographs, the intermediate distance image may seem superfluous. However, the distant photograph rarely captures enough detail to uniquely identify an injury. Up close, most areas of the body look surprisingly similar; as the close-up photograph eliminates the spatial relationship of the injury to the body and other injuries, wounds caused by the same weapon may be impossible to distinguish anatomically in photographs. For these reasons, it is recommended that all injuries be photographed from an intermediate range which includes an anatomic landmark (belly button, ear, knee cap, finger), in addition to the scale and unique identifying number.

The intermediate distance photograph additionally captures the relationship of injuries to one another. While the autopsy report describes the wound pathway, the intermediate range photograph can visually capture it. Usually, this can be achieved by a single photograph framing the related injuries. However, injuries significantly separated anatomically may be best demonstrated through the use of probes, adhesive numbers, and focus. If both points cannot be included in the same frame, serial photographs of a probe connecting the two will demonstrate the relationship. If the injuries can be framed together but have significantly different focal lengths, serial photographs from the same angle serially focusing on each injury can be helpful. Of note, related injuries are often best captured when the body is manipulated to the position at which the injuries likely occurred, and photographs of this positioning can be invaluable.

Of the three levels of autopsy images, the intermediate photograph is most likely to involve manipulation of the body, and thus some additional hurdles for the photographer. As unrelated anatomy enters the frame of the image, the potential for inflammatory content increases. Carefully placed towels shield unrelated aspects of the body (Fig. 9.2.6). Also, judicious use of lightweight uniform backgrounds can eliminate unnecessary distractions. Access to a step stool or safety ladder may be required as lenses with a high focal length may require an uncomfortable distance from the body in order to focus, particularly when the photograph is taken from overhead. The heavy lens can often begin to "slip" over time, and make focusing and framing a challenge. And, as discussed above, removal of extraneous material (gloved hands, autopsy equipment), and a clean environment are always beneficial.

Photography of Organs and Body Cavities

Documentation of natural findings, disease processes, and anatomic variants are as important to the determination to the cause and manner of natural deaths as injuries are to violent deaths. The purpose of the autopsy is to identify and document both natural and unnatural findings, and as such, examination of the internal organs and surfaces of the body are equally valuable.

Findings of the internal examination are usually best demonstrated through images of the organs and body cavities. Except to demonstrate findings which would be altered by the autopsy procedure, or to document a relationship such as a wound pathway, organs and body cavities rarely require a distant photograph encompassing the body. Photographs should include one image distant enough to capture the entire organ or cavity, as well as close enough to capture the fine detail being demonstrated (Fig. 9.2.7). The use of three levels is encouraged, but may not add significant information given the size of the organ or nature of the pathology. As such, protocol, image storage limitations, or time may dictate specific image criteria of these components.

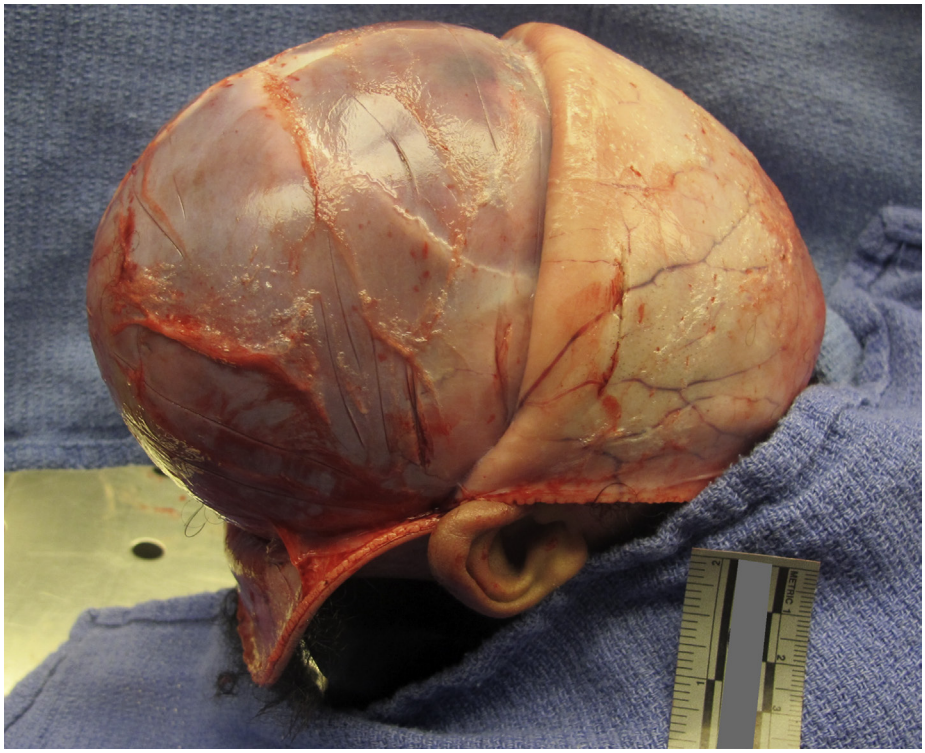


FIGURE 9.2.6
Photograph of the head after reflecting the scalp; towels are used to cover other aspects of the body.

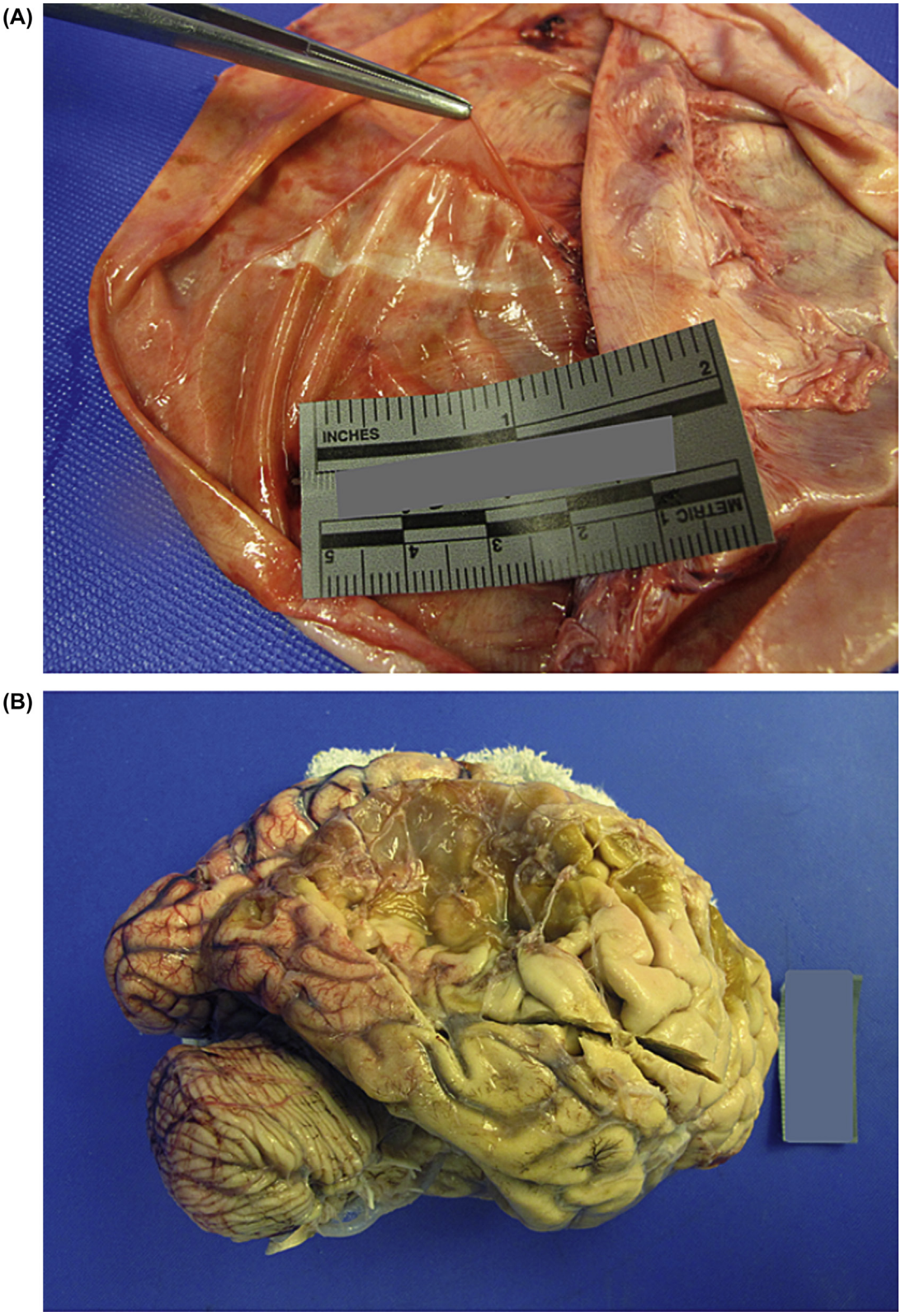


FIGURE 9.2.7
(A) Close-up photograph of the inside surface of the dura mater showing the fine detail of a neomembrane being held up by forceps. (B) Photograph of the entire brain showing a large area of depression from a subdural hemorrhage.

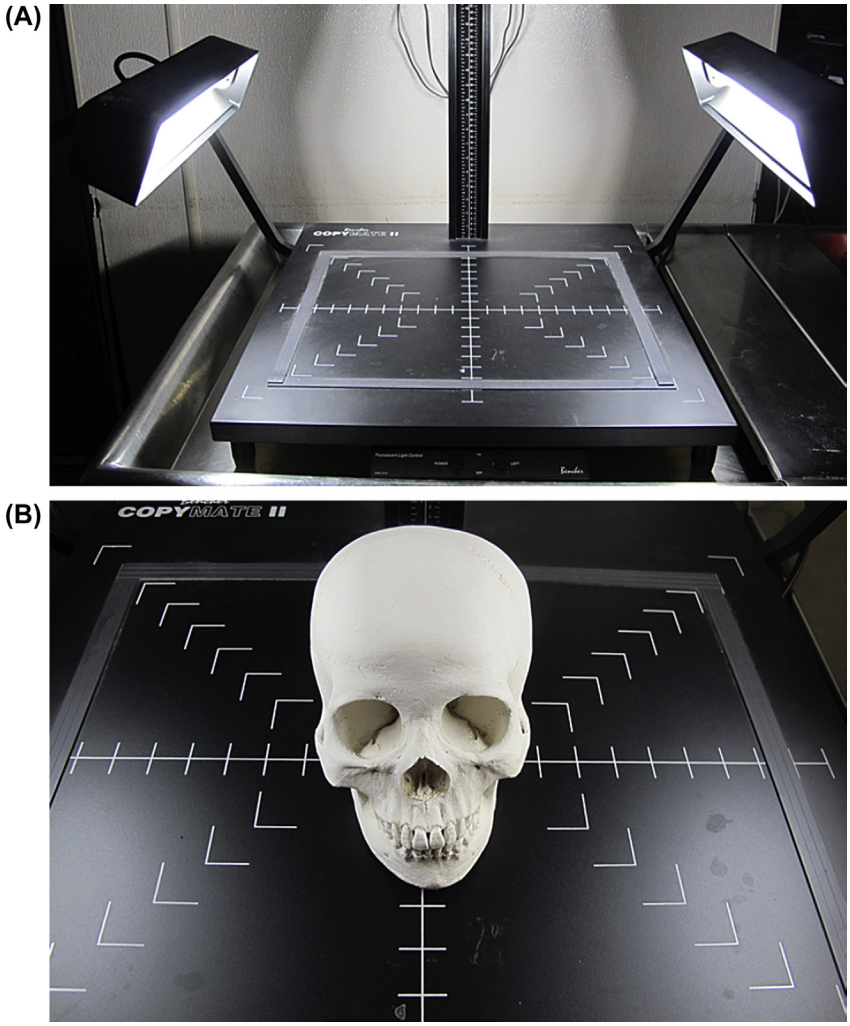


FIGURE 9.2.8
(A) Professional photo stand. (B) The contours and details of this skull are dramatically highlighted by the quality of lighting on a photo stand.

Unlike the body which cannot be significantly altered, the background upon which the organ is placed is easily controlled by the pathologist or the photographer. The area around the organ can be arranged to be devoid of biological fluids. The organ can be placed on the table to exclude use of hands, and clean forceps may be used to manipulate or accentuate specific areas. Organs may also be turned to compensate for disadvantageous lighting. Some offices invest in light boxes or photograph stands for imaging outside of the body cavity (Fig. 9.2.8). Although the usefulness of these conditions cannot be denied, it is also acknowledged that similar results can be achieved through less cost prohibitive techniques such as backgrounds, flashlights, and good scales.

Body cavities pose a unique problem for the photographer. These spaces are often curved, confined, with little to no access to light from the external surface. In order to demonstrate pertinent findings, the autopsy procedure will expose most cavities for inspection and photography. However, limited access to certain cavities still requires some creativity on the part of the photographer. Inevitably, the image of a curved cavity will result in most of the surface deviating from the perpendicular angle, requiring multiple angled photographs. For example, documentation of pertinent findings in the chest cavity will likely include photographs taken from the opposite side, from above, and from the inferior angle (looking up from the abdominal cavity) (Fig. 9.2.9). Use of an ABFO scale may be helpful if an injury is to be documented of a curved surface, particularly when photographing injuries of the internal surfaces of the skull. Lighting of curved or confined spaces is also problematic due to shadows obscuring the image. A simple flashlight held by an assistant will often resolve this problem. The flashlight beam may be directed onto the intended area from various directions, including from within a different body cavity. The oral cavity, for example, is exceptionally well demonstrated by photographs through the mouth after the neck structures are removed, and replaced with a flashlight illuminating the oral cavity from below (Fig. 9.2.10). Some offices have colposcopes available for photography of vaginal trauma or disease, but they are ideally suited for various other cavities as well, because of their magnification and long focal length.

SPECIAL TECHNIQUES

Ophthalmic Pathology

The eyes, as small curved surfaces with a reflective lens, represent one of the most difficult objects to photograph. Photography of the retina in situ requires special equipment, such as a funduscopic camera, or special techniques.

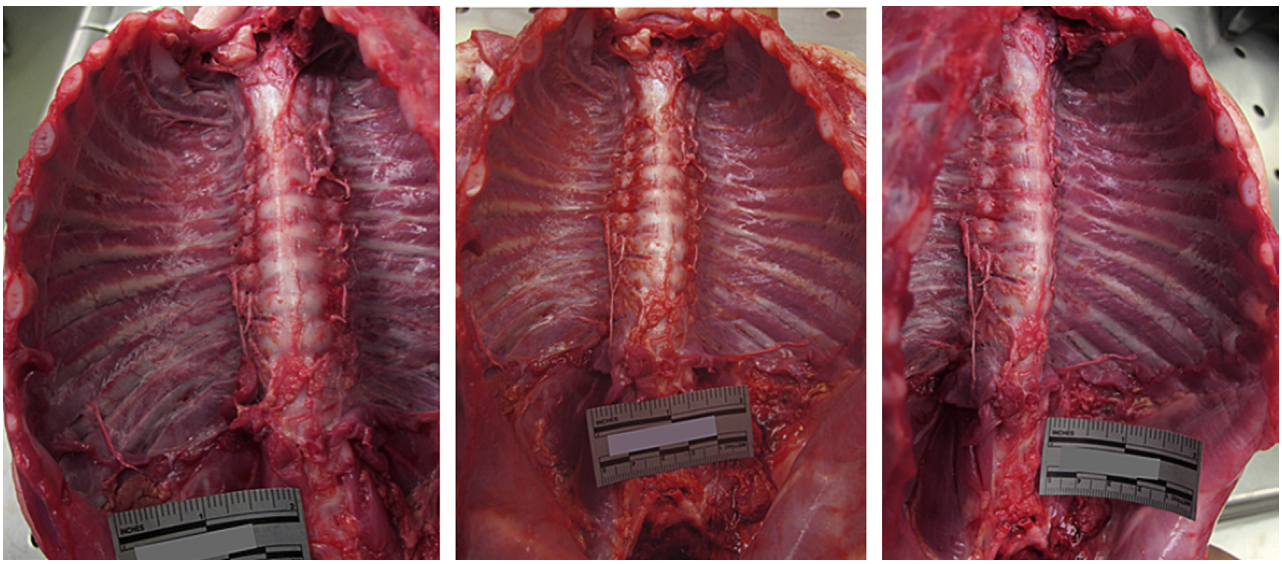


FIGURE 9.2.9
Photograph of the eviscerated thoracic torso taken from the left side, from directly above, and from the right side.

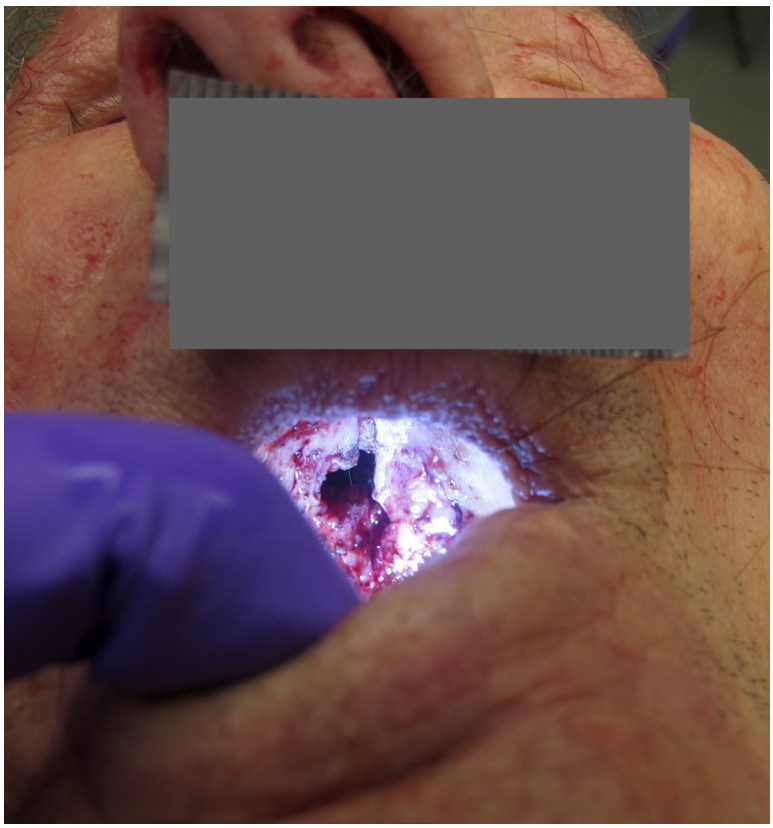


FIGURE 9.2.10
Inside of mouth lit through the neck with a flashlight after the neck structures were removed.

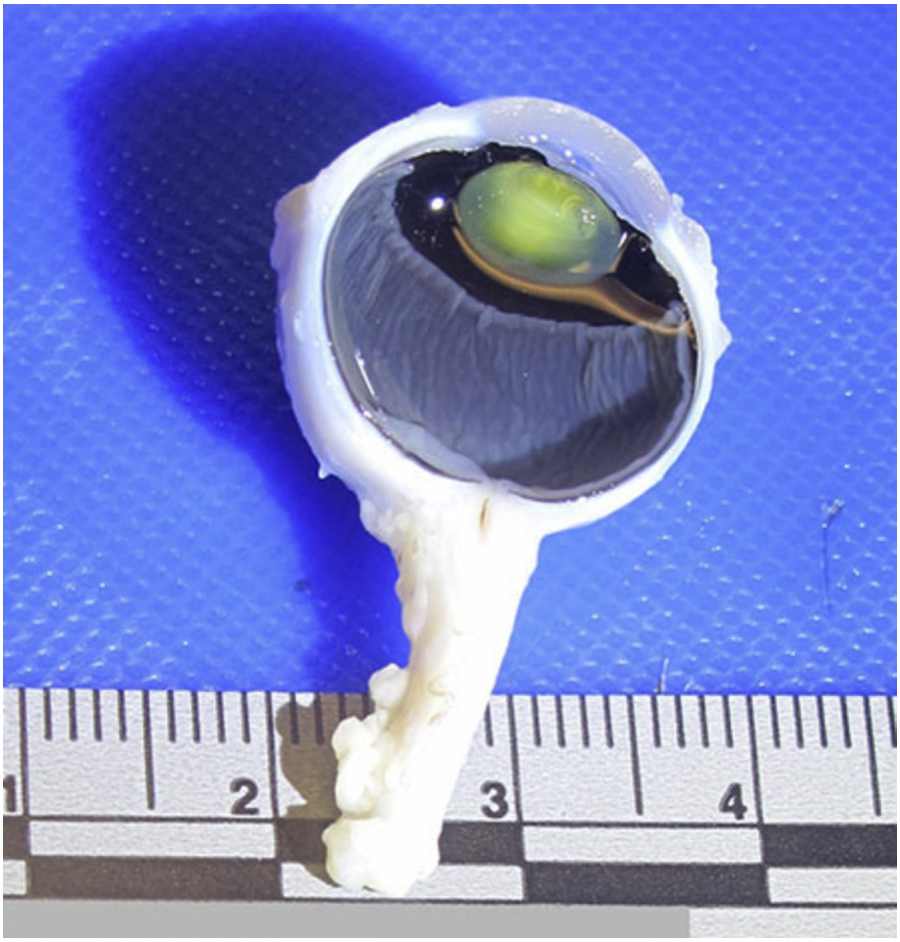


FIGURE 9.2.11
Photograph of the eye after fixation and bisection showing the absence of retinal hemorrhages.

Generally, the eyes will be fixed and then examined after bisection as half-domes or three-fourth globes. The dark concave internal surfaces of the eye are best visualized and photographed in a controlled environment. Specifically, the internal aspects of the eyes are best visualized in a bowl of water or saline, on a black felt background. The felt background helps absorb refracted light, while the water stabilizes the deflated globe. However, with proper support such as a towel, clay block, or sponge, the eyes can also be stabilized on a table or cutting board. A small flashlight (preferable multiple submersible flashlights if photographing in water) is mandatory, as the best results are obtained when overhead and ambient lighting is removed; the light from a flash will create shadows within the globe and obscure most of any image taken (Fig. 9.2.11). These photographs are best accomplished with an assistant who can manipulate the light to the needs of the photographer, as rarely will one single photograph capture the entire surface. The delicate nature of the eye mandates that the photographer move to capture the image, rather than manipulating or rotating the eye.

Fragile and Distended Organs

In some instances, the organs may be so damaged by injury or natural disease that they lose their anatomic integrity. These fragile specimens often do not photograph well on a table, as gravity naturally collapses labile tissue. In these cases, the use of a water medium can suspend an organ and its pertinent structures so as to demonstrate the level of deviation from normal [eg, the "floppiness" of a distended mitral valve (Fig. 9.2.12A)]. Additionally, a water medium may preserve a brain almost entirely obliterated by hemorrhagic stroke, thus demonstrating the fragility of the tissue, as well as the three-dimensional disruption of the structure (Fig. 9.2.12B). In general, photographing through water does not require any augmentation of equipment. However, as the refractive index of water influences measurements, the organ should also be photographed outside of the liquid medium with an appropriate scale.

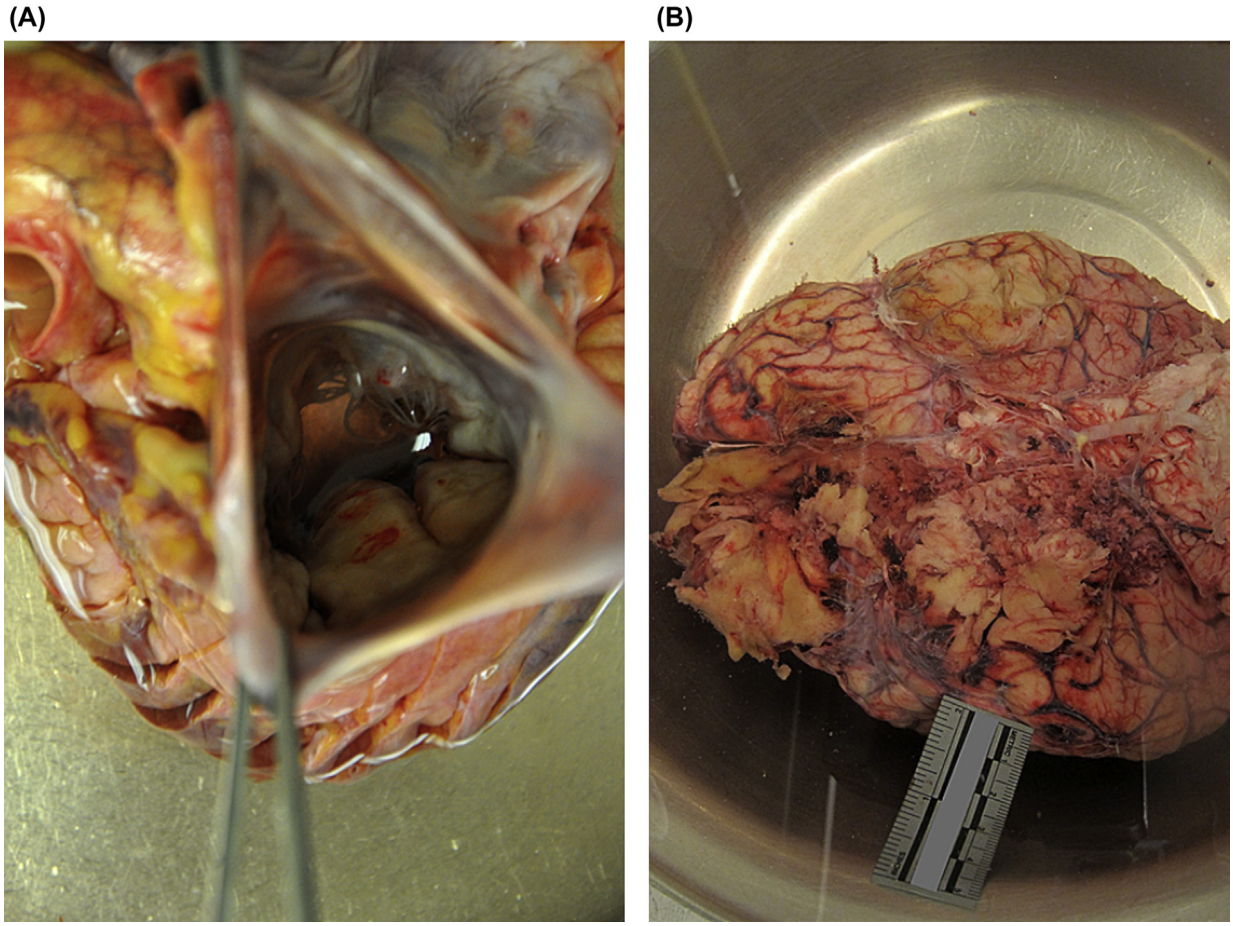


FIGURE 9.2.12
(A) Photograph of a mitral valve of the heart from above showing the incompetence of the valve from mitral valve prolapse due to a floppy degeneration. (B) Photograph of the base of the brain in a pan of water showing the destruction of the underside of the left frontal lobe by a stroke.

Air Emboli

Certain autopsy findings are transient in nature. In particular, the displacement of air into inappropriate cavities cannot be visualized with standard autopsy techniques. Neither can it be captured photographically, as air from a cavity cannot be distinguished from air anywhere else in the photograph. In such instances, the presence of air is demonstrated by the displacement of water in a syringe. Although it does not require any special technique on the part of the photographer, it behooves the autopsy photographer to be prepared to document a rapid and dynamic process that cannot be repeated.

Tattoos

Tattoos are photographed for identification, but also possible gang relations. Most tattoos are photographed as are external injuries. If the body manifests skin slippage, the removal of the outer skin layer can enhance the tattoo. However, darkening of the skin by decomposition can obscure a tattoo and then UV or IR photography as described elsewhere can be important and striking. It is also useful to employ these techniques when fluorescent dyes are used to create "invisible" tattoos or even if a traditional tattoo has faded.

LEGAL ASPECTS

Photographs are often shown in court, to include autopsy photographs (Kenner; SWGIT; Kashi, 2006). Typically the photographs to be introduced will be selected from the many available photographs and the order of the photographs determined during a pretrial conference with the attorney proffering your testimony.

At trial, a *foundation* must be established for photographs to be admissible into the court record and examined by the jury. Autopsy photographs, like all photographs, sought to be admitted into court are governed by Federal Rule

of Evidences (FRE) 901 and 1001-8, and their state equivalents. These rules declare that a witness with appropriate knowledge may *authenticate* an item of evidence through testimony that it is what it is claimed to be.

Two elements are necessary for a witness to authenticate photographs: (1) the identification of the photograph, and (2) that the image accurately represents what it is claimed to show. Thus, the forensic pathologist should expect to be asked if he or she recognizes the photograph, to describe what the photograph depicts, and that the photograph truly and accurately describes what is depicted. The forensic pathologist must have first-hand knowledge of what is depicted, based upon their own personal eye witnessing the body and the injuries which were photographed.

Autopsy photographs are considered to be illustrative or explanatory of the forensic pathologist's testimony to help the jury better understand the testimony. As such the photographs are secondary demonstrative evidence to the primary testimonial evidence. In other words, when used merely as demonstrative evidence, the rules regarding authentication and chain of custody will be applied in a relaxed fashion where a competent witness testifies that the photograph fairly and accurately depicts the scene about which he or she is testifying. Furthermore, the authenticating witness need not be the photographer or even the observer of the making of the photograph [*United States v. Clayton*, 643 F.2d 1071, 1074 (C.A. 5, 1981)]. Moreover, in this situation, duplicates will typically be admitted to the same extent as original photographs, unless a genuine issue of authenticity is raised. Also, the original photograph may be considered public records, in which case FRE 1005 recognizes that duplicates will suffice.

The authentication requirements will be stiffened in the face of the rare strong argument over the accuracy of the photograph. Courts are usually willing to tolerate some inaccuracies in a photograph if explained to the jury so that they may be taken into account. The metadata stored in photographic files from modern cameras will likely contain enough nonevident metadata to detect most alterations and may help authenticate the photograph. Generally, a trial court's admission or exclusion of proffered photographs is reviewed under an abuse of discretion standard.

Autopsy photographs are most likely to be objected to and excluded if they are considered to be inflammatory or prejudicial. FRE 403 states: "The court may exclude relevant evidence if its probative value is substantially outweighed by a danger of one or more of the following: unfair prejudice, confusing the issues, misleading the jury, undue delay, wasting time, or needlessly presenting cumulative evidence." The interpretation of this evidentiary rule tends to be based on understandings within local legal communities—so that one interpretation will prevail in one area of the country and another elsewhere. In general, the interpretation has become more lax, particularly as juries have become more accustomed to more explicit, graphic, and prevalent violence on television and in other media. For example, some jurisdictions would permit only black-and-white photographs, but color photographs seem to be the norm in virtually all jurisdictions these days. It is clear that autopsy photographs are valuable, despite some inherently emotional images; photographs of wounds have been uniformly held to be admissible in criminal cases (*Franklin v. State*, 69 Ga. 42; *People v. Fish*, 125 N. Y. 136). The photographer can keep a photograph less inflammatory by cleaning up the injury, particularly any extraneous blood, and keeping the injury from entirely filling the frame. Perhaps, it is better said that the photographer should take the photograph with respect to potential jurors' sensitivities in mind.

It should be noted that where a photograph is not admitted, the forensic pathologist may still testify as expert witnesses testifying under FRE 703, or as an eyewitness, to whatever might have been photographed.

Further Reading

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APPENDIX

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Additional Examples of Autopsy Photography

Two of the most frequently asked questions at death scenes are, "Has the deceased been identified yet?" and "How long have they been dead?" The answers to both are crucial to any criminal investigation.

There are many ways to identify a person, but the easiest methods of doing so—by being recognized by someone who knows them and by finding identification papers in their wallet or purse—are sometimes not available. As mentioned above, sometimes scars, marks, and tattoos or some other distinctive trait, like wearing unique multiple earrings or engraved jewelry also prove to be helpful to identify the deceased. However, these should always be substantiated with scientific means of identification whenever possible. During the autopsy, identifiable objects are sometimes found on or inside the body. Fig. 9.2.13 shows some of the frequent finds that can ultimately identify a body. These may have the name of the deceased on them, serial numbers may be traceable to an individual, or they may be recognized by family or friends.

Fingerprints and dental work are frequently used to identify a body which is no longer recognizable to family, friends, neighbors, or co-workers. Even when the body is decomposed badly, fingerprints can still be located on mummified and decomposed bodies, like in Fig. 9.2.14.

Determining the Postmortem Interval can be done during the early stages after death by documenting commonly encountered artifacts which occur in predictable time intervals, Fig. 9.2.15 shows several of these. It is important to photographically document these findings as soon as possible because they will change over time.

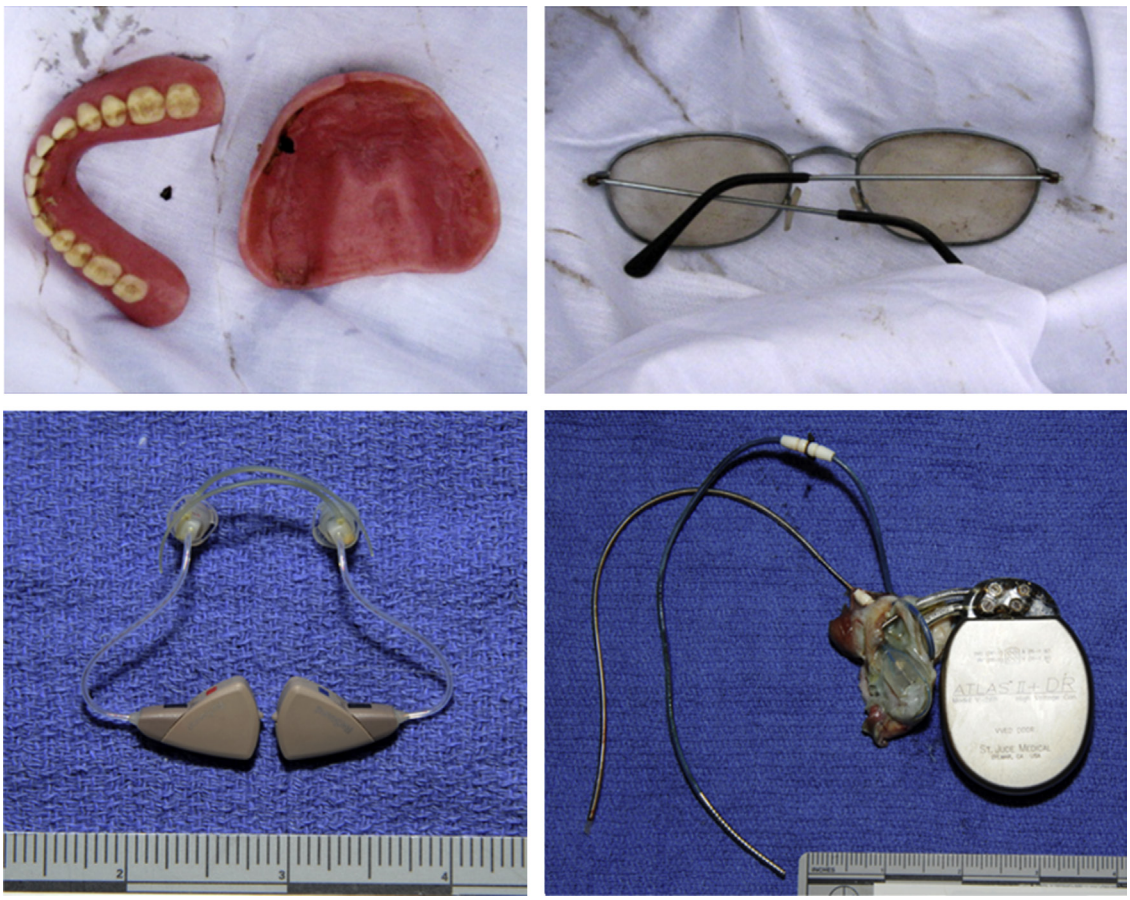


FIGURE 9.2.13
Items recovered during autopsies which can assist in determining identity: dentures, prescription glasses, hearing aids, and a pacemaker.

Documenting the wounds and injuries which may be responsible for the death is one of the most important aspects of autopsy photography. It is no surprise that shootings and stabbings account for a large majority of deaths, and such wounds must be photographed "as is" and at various stages of the autopsy. As stated above, these wounds will have to be photographically documented through the standard progression of overalls, intermediate, and close-up photos.

With a gunshot wound, the range-of-fire may sometimes be estimated by the presence and pattern of stippling (tattooing). At longer distances, gunshot residues (GSR) exiting the barrel will not reach the target, or will be sparse if it



FIGURE 9.2.14
Mummified skeletons may still have sufficient friction ridge detail of the fingerpads for ID.



FIGURE 9.2.15
Postmortem changes to the body during decomposition: bloating, marbling, skin slippage and lividity.

does. As the shooter gets closer and closer to their victim, the tattoo pattern becomes smaller and denser, such as in Fig. 9.2.16. On the left, the gunshot residue has reached the victim, but is not as dense as the pattern seen on the right.

Let us revisit Fig. 9.2.5. Although there is a lack of stippling around the entry wound, there does appear to be a muzzle imprint around the wound, visible in Fig. 9.2.5B. In such instances, the muzzle imprint confirms this was an entry wound, not the presence of stippling or tattooing.

Examine the wound in Fig. 9.2.17: is this a large stellate entry wound or an exit wound? That the wound site appears to be depressed and concave is not conclusive. Skull fragments may have blown outwards, leaving little support for the tissue in this area. However, you may be able to see, in the 11 o'clock position of the wound, what appears to be a round muzzle imprint. Of course, examining the opposite side of the head would probably provide confirmatory evidence at that wound site. Also, if this were a stellate entry wound, there should also likely be ample GSR between the skin and the skull.

On a related matter, as in Fig. 9.2.18, many times an X-ray may be helpful in determining just what happened. It is useful to know that X-rays are usually very easy to photograph. They are backlit with enough light to be metered and photographed without flash. As the X-ray on the left demonstrates, many shotgun pellets remain in the skull. The rear of the skull appears fractured with most pellets there, and the lower right mandible does not appear as well defined as the jaw in the X-ray on the right. This suggests the trajectory.



FIGURE 9.2.16
The density and diameter of tattooing can help determine the range of fire. On the left, the gunshot residue has reached the victim, but is not as dense as the pattern seen on the right.



FIGURE 9.2.17
Entry or exit wound?

At times, the best way to make sense of multiple gunshot wounds is for the Medical Examiner to use a probe to demonstrate trajectory or directionality. Fig. 9.2.19 is a case in point. Raising the left arm a few inches has the alignment of the rod fit just a bit better, and more accurately demonstrates the position of the victim when shot.

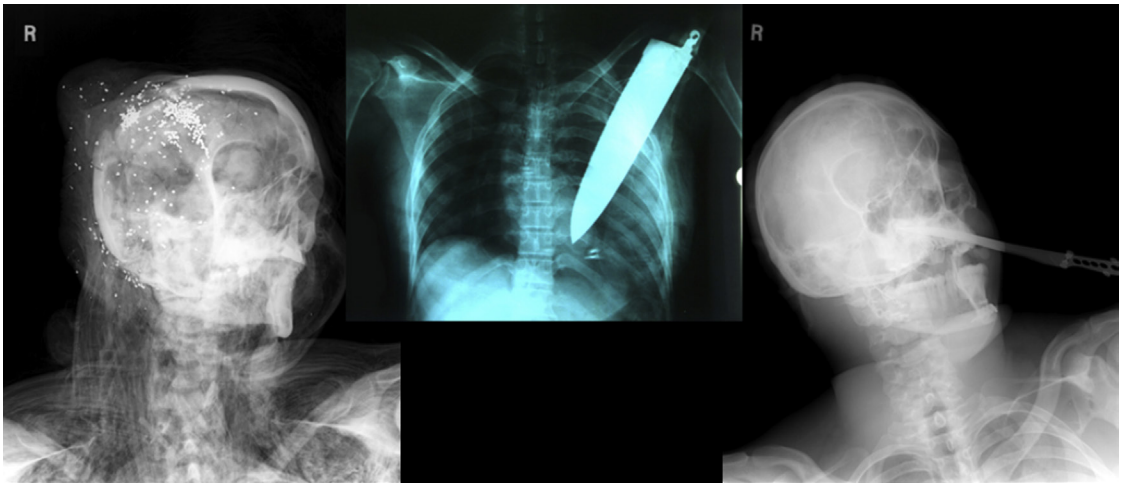


FIGURE 9.2.18
X-rays of foreign materials.



FIGURE 9.2.19
Rods can help demonstrate a bullet's trajectory.



FIGURE 9.2.20
Stab Wounds. On the right, articulating the wound so it gapes less to better determine the blade shape.

At stabbing scenes, deadly wounds to the torso, neck, and head can result. Fig. 9.2.20 is a typical result. To better approximate the shape of the blade, the Medical Examiner gently pushes the sides of the wound closer together, as is shown in the right image. This is because the underlying musculature may cause the stab wounds to gape wider than the blade, effectively making the blade look shorter than it really is. This is related to the skin's elasticity and Langer's lines. Two stab wounds made by the same knife blade, if perpendicular to each other, may have one appear long and narrow and the other gaping and looking shorter. This is not a sign that two different weapons, held by two different attackers, killed the victim. A knowledge of the directionality of the muscle tissue beneath the exterior wound accounts for this difference. And finally, one type of evidence at death scenes, which can help determine the postmortem interval, is the presence, variety and development of insect larvae on, in and around the body.

For a postmortem interval determination to be attempted it is necessary to have the adult stage of the insect, so if this is an issue in your case, collecting some and rearing them to adulthood will be necessary. The process, of course, begins with the photographic documentation of the larvae. A good macro lens is necessary, and the goal should be to collect examples of the oldest/largest available. Then, you too can capture an image like the one in Fig. 9.2.21.



FIGURE 9.2.21
Photographic documentation of larvae.

SUBCHAPTER 9.3

Bloodstain Pattern Analysis and Photography

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Documenting bloodstain patterns and stains through photography can be difficult for the crime scene specialist, but if the following guidelines and methods are applied, great photographs can be achieved. Photo documentation through roadmapping and grid techniques is explained to assist in managing a scene with multiple bloodstain patterns and stains. This section assumes the photographer has basic bloodstain pattern analysis training.

PHOTO DOCUMENTATION THROUGH ROADMAPPING

Entering a violent crime scene where multiple surfaces are covered with blood can be stressful for any crime scene technician, investigator, or analyst. In these situations, crime scene personnel often take out their cameras and begin photographing without a systematic or organized approach. Roadmapping is an efficient way to manage and photograph multiple bloodstain patterns on one or multiple surfaces. The roadmapping method requires that every photograph (after the in situ photographs) have a label and scale to provide reference to the location of each photograph with respect to the scene and other patterns and stains. For example, the viewer can examine a close-up photograph of a portion of a bloodstain pattern and understand where it is located within the scene based on its relationship with other photographs. Before photo documentation with the roadmapping technique can proceed, the crime scene specialist must prepare the bloodstained surface through the use of scales, labels, and other aids to visually assist with orientation, movement of the bloodstain patterns, or even the area where a DNA sample was collected.

Wolson (1994) coined the term roadmapping as a method to document multiple bloodstain patterns and stains at a crime scene. The following is a list of guidelines for photo documentation through use of the roadmapping technique:

- Identify distinct bloodstain patterns and stains.
- Photograph the overall surface or surfaces containing the patterns and stains in situ before labels or scales are introduced.
- Photograph each distinct pattern in situ without labels or scales.
- Outline the perimeter of the area containing all the patterns and stains with large vertical and horizontal scales.
- Place sequentially numbered labels and scales adjacent to each individual pattern or stain.
- Add guides to assist the viewer (eg, arrows).
- Photograph the overall surface or surfaces containing the patterns and stains with the labels, scales, and guides in place.
- Photograph each individual pattern or stain with labels, scales, and guides in place.
- Take close-up photographs of important pattern details or individual spatter stains used for analysis.
- If necessary, create convergence lines for impact patterns and photograph the convergence.
- If necessary, create an area of origin with strings and photograph from various angles (assuming forensic bloodstain pattern software is not used).

After identifying distinct bloodstain patterns and stains, the first set of photographs should be of the target surfaces (eg, walls, floor) that contain the various patterns prior to the placement of scales, labels, or guides. Fig. 9.3.1 shows an in situ photograph of a vertical wall containing multiple bloodstain patterns. It is imperative to keep the film plane (digital sensor) parallel with the surface containing the patterns. Mounting the camera on a tripod provides stability when composing, is useful for proper exposure in lower light conditions, and provides a means of attaining an improved depth of field. A 50 mm lens is preferred for overall photographs and a macro lens is preferred for close-up photography.

Before labels, scales, and guides are fastened to the target surface, a set of in situ photographs of each distinct pattern or stain should be completed. After completion of the in situ photographs, the crime scene specialist affixes easily visible scales oriented vertically and horizontally on the surface around the perimeter of the area where the patterns or stains



FIGURE 9.3.1
A wall with various bloodstain patterns before any label, scale, or guide is introduced.

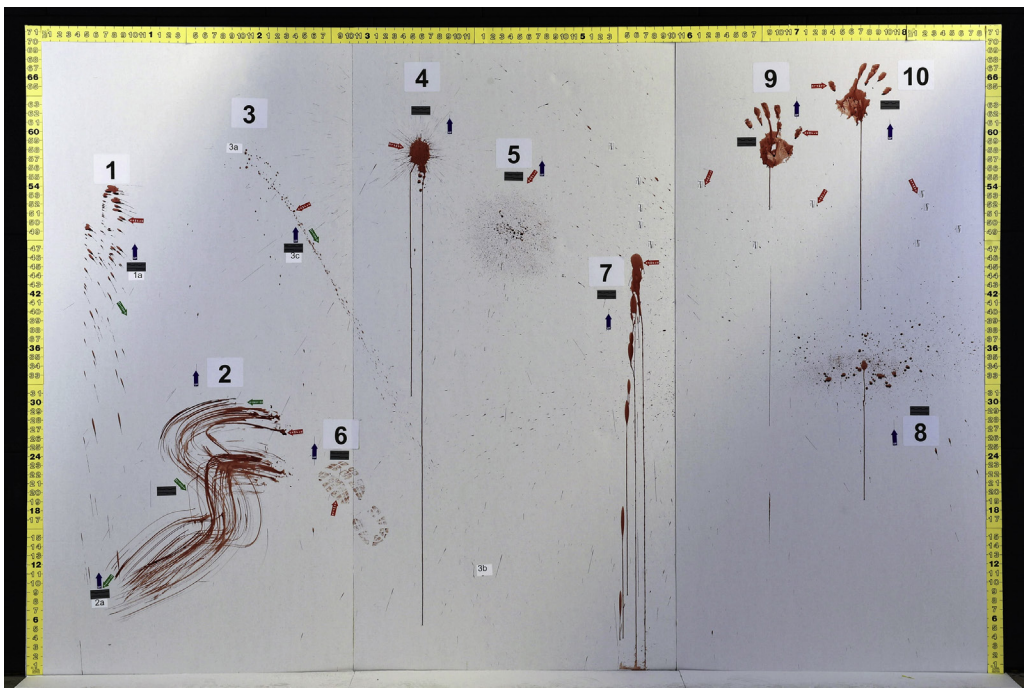


FIGURE 9.3.2
Roadmapping technique with perimeter scales, labels, and guide arrows.

are located. One way to think about preparing the surface for photo documentation is that the bloodstain patterns and stains on the surface are the picture while the scales around the perimeter are the picture's frame. The use of a level will assist in placing the vertical and horizontal scales on the target surface. The numbers on the perimeter scales should be large enough to be read when viewing the overall photographs. Fig. 9.3.2 shows bright yellow and easy-to-read perimeter scales that help orient the viewer to the locations of the patterns and stains on the surface.

Many crime scene photographs are taken from a natural perspective where the camera is at the photographer's eye height. However, using the natural perspective on a wall with scales running vertically from the floor can distort and skew the appearance of the scales. Lowering or raising the camera height to near the center of the area bordered by the vertical and horizontal scales can assist with keeping the scales looking proper. In addition, when photographing individual patterns or stains, the lens should be centered so that angle distortion is not introduced.

The subsequent step in preparing the surface for photo documentation is to place large numbered or lettered labels adjacent to each pattern. The labels should be sequentially ordered so each pattern or stain has its own number or letter. The labels should be large enough to be identified in the overall photograph. Fig. 9.3.2 demonstrates the use of large preprinted labels affixed to a wall identifying the various patterns and stains. If preprinted labels are not available, large Post-it notes or similar labels can be used.

In addition to labels, scales are also applied adjacent to each pattern to include them in the photographs. At least one scale is attached to each pattern; however, the use of multiple scales is acceptable where a pattern or stain encompasses a large area or specific detail in the pattern requires close-up photography. Some crime scene specialists affix scales that encompass the entire length and width of a pattern or stain while others prefer smaller scales. As long as a scale is located within a photograph, its size is irrelevant as patterns and stains can be measured from the photograph or at the scene. It is a matter of preference regarding which size scale to use as long as the hash marks are in focus in the photograph.

Every photograph of individual patterns and stains should contain a scale and label corresponding to the pattern being documented. Close-up photographs focus on a stain or pattern's detail that is informative or used for analysis. Large labels should not be used for close-up photography because they take up pixels that could be better utilized focusing on the stain or pattern's detail. The crime scene specialist can write the stain or pattern number or letter on the scale used in the close-up photograph or use a smaller sublabel. It is imperative that the scales in the pattern and close-up photographs be readable.

Guides of various types can be placed on the surface and included in the photographs. An "up" or "north" guide can be composed in the photograph to assist with orientation. Crime scene photographers often fill the frame by rotating the camera so the long axis of the pattern or object corresponds with the long axis of the camera's viewfinder. Orientation issues can occur, for example, when a pattern with a long axis is oriented at a diagonal on a vertical surface and the photographer rotates the camera to fill the frame with the pattern's long axis. When the photograph is viewed, the pattern appears horizontal and not in its original diagonal position on the wall. In this example, the person viewing the photograph may assume the pattern is oriented horizontally on the wall and the top of the photograph is up. In this example, an "up" guide arrow would assist in orienting the true position of the pattern. Another type of guide placed in the photograph can be a "directional" arrow. This assists the viewer in comprehending the direction of the bloodstain pattern or stain's travel upon impact.

After all labels, scales, and guides are in place, overall photography of the entire surface containing the patterns and stains can begin. Following the overall area photographs, each distinct pattern or stain is photographed. Fig. 9.3.3 is a photograph of a transfer stain with a large label identifying it as stain 9. Close-up photographs of important details in various patterns or stains usually follow. An important area of detail in a pattern can be sublabeled as shown in Fig. 9.3.4 where sublabel 2a is affixed to the lower left portion of a swipe pattern to document detail that is consistent with hair swipes (or similar) and to assist with the pattern's direction of travel. Sublabel 2a is associated with pattern 2 based on its number and the pattern photographs. Fig. 9.3.4 includes a close-up portion of pattern 2 using a sublabel for reference, a scale, and "up" and "directional" guide arrows (patent pending for guide arrows).

After identifying and documenting the patterns and stains, one can begin to reconstruct an area of convergence and origin if warranted. Well-formed spatter stains from an impact pattern are selected and labeled. Close-up photographs of each selected stain used for areas of convergence and/or origin analysis is mandatory. Each spatter stain should be marked with a small scale, such as a 20 mm scale, along with the stain's number and a plumb line. Refer to Fig. 9.3.2 for the locations of the selected spatter stains used in the reconstruction of impact pattern 8 (small scales in the upper right quadrant of the photograph). The stains chosen from pattern 8 are sequentially ordered so that each stain has its own number (eg, 8.1, 8.2, 8.3). A plumb line should be added to each scale associated with each stain so a bloodstain pattern analyst can reconstruct the pattern with computer software based on the photographs and measurements of each chosen stain. The plumb line allows the forensic software program to calculate a directional angle for the stain. A simple method for creating a plumb line on a scale is to draw a straight line along one of the edges of an angle finder.

To photograph individual spatter stains of an impact pattern, the film plane must be parallel and an attempt must be made to fill the frame with the stain and the scale with the lens used. Fig. 9.3.5 is a photograph of the ninth stain selected from pattern 8 and includes a scale, the stain's number, and a plumb line. It is preferable to place the scale opposite the stain's direction of travel so when convergence lines are drawn, they do not cross over the scale.

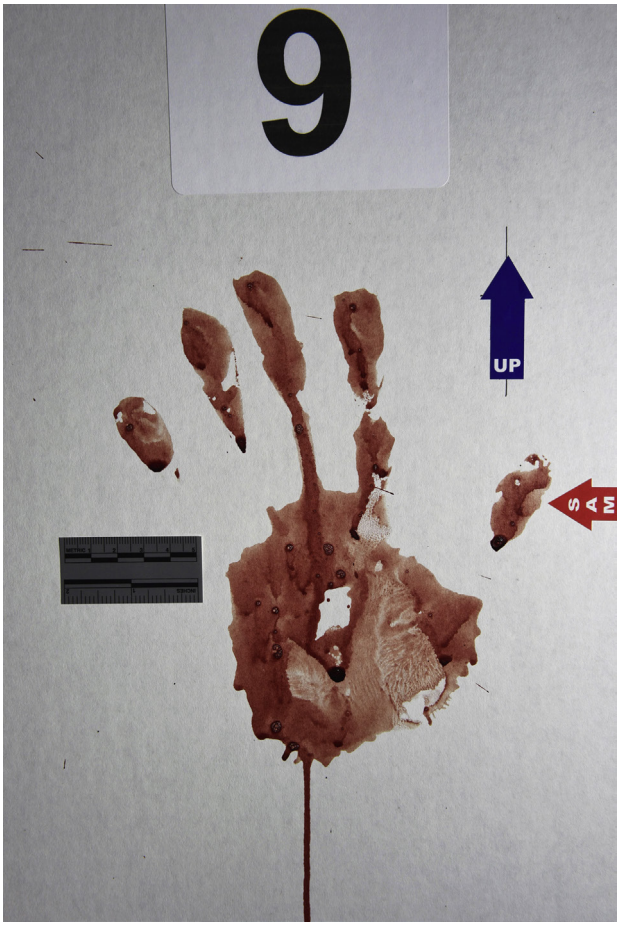


FIGURE 9.3.3
A photograph of transfer stain 9. Included in the photograph are a scale, the stain's label, an "up" guide arrow, and a "sample" arrow indicating where the stain was swabbed for DNA.

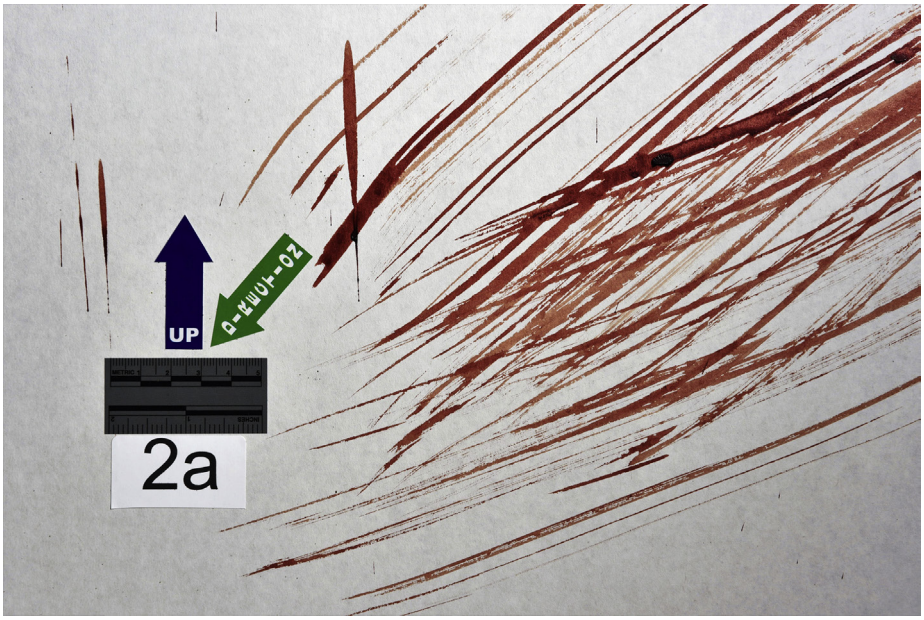


FIGURE 9.3.4
A close-up photograph of a portion of pattern 2. Sublabel 2a located in the close-up photograph makes it readily apparent to the viewer which portion of the pattern is being displayed.



FIGURE 9.3.5
Small spatter stain with an adjacent scale documenting the stain number and plumb line.



FIGURE 9.3.6
Plastic tube attached to the end of the camera's lens used for close-up photography.

Fig. 9.3.5 was captured with a Nikon 60 mm macro (micro) lens with an attached plastic tube that screws onto the front of the lens. The benefit of this device, as seen in Fig. 9.3.6, is that if pressed against a flat surface it assists in keeping the film plane parallel with no need for a tripod as long as the shutter speed is no slower than 1/60 of a second. Even though the plastic tube assists with stability, slight movement may occur over a longer shutter speed, causing the photograph to blur. The length of the tube used with the 60 mm lens allows for a 2:1 magnification ratio. One can use a tripod, prefocus the lens to its closest focusing distance, and then move the camera to the bloodstain until it is in focus; however, when the tube is against a surface, it is automatically at its closest focusing distance. The plastic tube also permits the photographer to get into areas that may be awkward for a tripod to photograph small items of evidence. On curved surfaces, the tripod prefocusing technique is preferred.

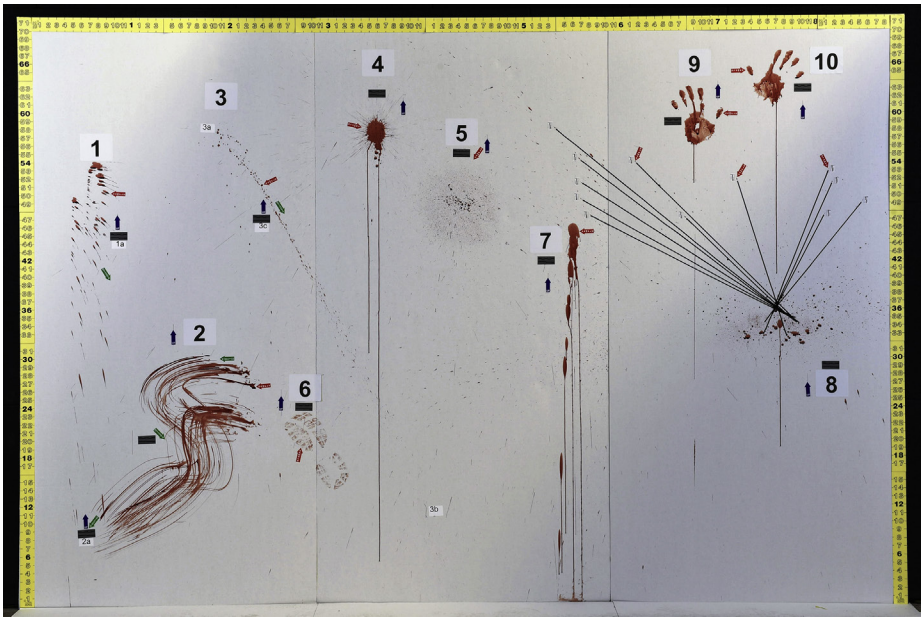


FIGURE 9.3.7
Convergence lines created on a wall with art tape.



FIGURE 9.3.8
Area of origin created on a wall with string.

After choosing and documenting spatter stains from an impact pattern, convergence lines can be created by drawing on the surface or by using art tape. Art tape works well to visually display convergence lines, as noted with regard to impact pattern 8 in Fig. 9.3.7. Different colored art tape can be used to differentiate various impact patterns.

The next step in the roadmapping photo documentation technique is to complete an area of origin reconstruction, if warranted. Fig. 9.3.8 shows strings attached to the leading edge of each bloodstain selected for analysis, with the other end of the string attached to a yardstick. The strings provide a three-dimensional reconstruction of the area of origin where force was applied to a blood source. One should photograph the area of origin from various angles, including the distance from the wall where the strings attach to the yardstick in three-dimensional space. A yardstick works well for documentation purposes, as seen in Fig. 9.3.9.

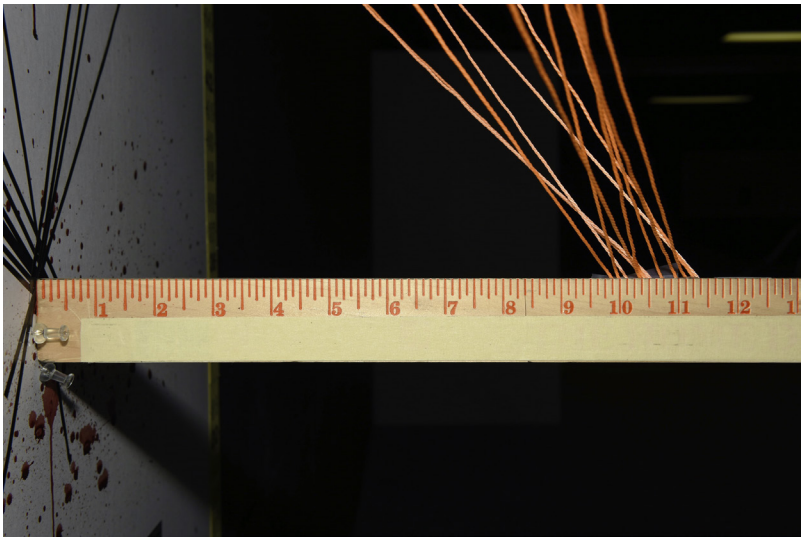


FIGURE 9.3.9
A photograph of an area of origin reconstruction showing the distance from the wall.

When photographing individual stains, patterns, or details of patterns used for analysis, it is important to photograph in the "sweet spot" apertures. F/11 is an f-stop to consider for these types of photographs to minimize lens aberrations and diffraction. Patterns or stains used for analysis should be captured photographically with a lossless image file format such as RAW or TIF. A lossy format such as JPG is great for compressing and reducing file size, but at the expense of discarding pixels and adding artifacts each time the file is decompressed and saved.

During the processing of a crime scene where bloodstain patterns and stains are present, it is necessary to collect a sample or samples from each pattern or stain to determine the identity of the blood through DNA. Photographs document the pattern, but the location where the sample was collected for DNA is often missing. An easy method to photo document where a sample was collected is to add a "sample" arrow or other guide. This allows the photograph to document not only the pattern, but also where the sample was collected. Fig. 9.3.3 is a photograph with a portion of a red "sample" arrow indicating what part of transfer stain 9 was swabbed for DNA. Fig. 9.3.7 is an overall photograph with "sample" arrows included for each pattern; these should also appear in the overall area photographs. Photographs of the area sampled for DNA should be taken after collection.

Roadmapping can also be used to document bloodstain patterns and stains on clothing. Fig. 9.3.10 shows a shirt with various bloodstain patterns and stains on its front surface. The shirt is surrounded on all sides by easy-to-read yellow scales with individual patterns and stains receiving their own label and scale. After overall photography with scales and labels in place, individual patterns or stains with scales and labels are photographed. Guide arrows or similar pointers can also be placed on articles of clothing for photo documentation.

PHOTO DOCUMENTATION THROUGH THE GRID METHOD

Another way to document a surface or surfaces with multiple bloodstain patterns and stains is with the grid method. With this method, the surface containing the patterns or stains is gridded into 2′ × 2′ squares, or any size squares depending on the size of the surface and the density of distinct patterns or stains. Each grid is labeled using vertical numbers and horizontal letters, or vice versa. For example, in Fig. 9.3.11, the upper left grid is labeled as A1, the grid to its right is A2, and the grid below A2 is B2. If warranted, each 2′ × 2′ grid can be divided into 1′ × 1′ sections or smaller for more detailed examination.

Prior to establishing the grid, the surface area containing all the individual patterns or stains should be photographed in situ. The grid can be established after the in situ photographs are complete. Each grid is photographed individually before any labels, scales, or guides are put in place. For pattern identification, a photograph for each pattern or stain is taken with labels, scales, and guides in place. If an area of convergence is reconstructed, a close-up photograph of each stain analyzed should include a scale and stain number. If an area of origin is reconstructed, close-up photographs of each individual stain used for analysis should include a scale, the stain's number, and a plumb line. A plumb line is preferable, but not mandatory unless the stain will be analyzed with forensic bloodstain analysis software. One never knows when a bloodstain pattern analyst may be required and putting a plumb line in the photograph is a quick and easy option to provide for this contingency.



FIGURE 9.3.10
Roadmapping method for a shirt.

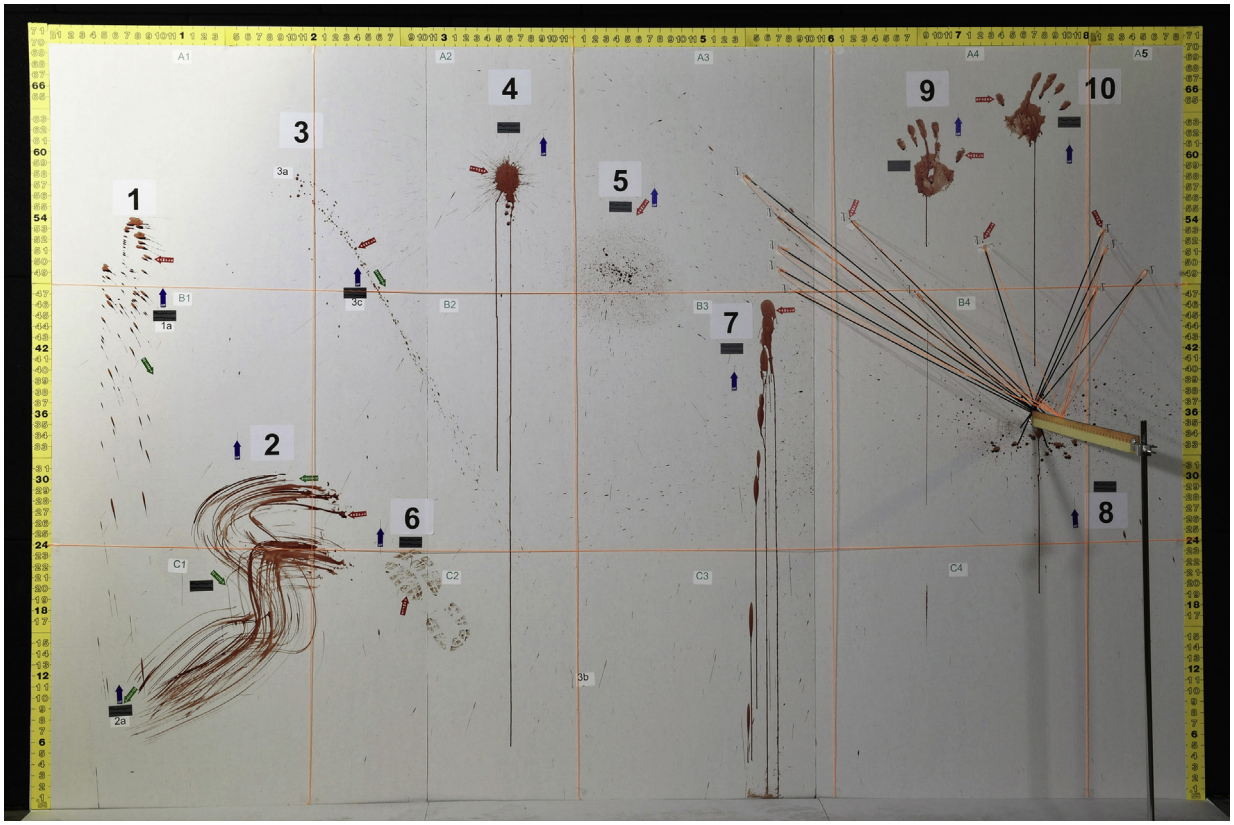


FIGURE 9.3.11
The grid method. Note that each grid has its own identifier (eg, A1, A2, B1).



FIGURE 9.3.12
The use of round reinforcement labels to illustrate where small spatter stains are located on a dark pair of jeans.

SMALL SPATTER STAINS ON CLOTHING

When a forceful impact event occurs, such as a beating or shooting, the associated blood spatter stains are often small, making them difficult to visualize. If the crime scene specialist wants to document the locations of very small spatter stains on clothing, especially on dark-colored fabrics, round reinforcement labels can be used to mark the locations of the stains, as shown in Fig. 9.3.12. The round reinforcement labels can be placed around the stains and removed after photography has been completed. Be sure not to lick or moisten the stains prior to applying the reinforcement labels. Photography and the collection of samples for DNA should precede the placement of reinforcement labels.

LIGHTING

Sufficient lighting should be brought to bloodstained scenes, especially if the light is dim or shadows exist. Portable floodlights work well as they can be positioned where needed. Spatter stains associated with explosive force (eg, shootings, explosions, high-speed machinery) are often less than a millimeter in diameter and without proper lighting may be missed during crime scene evaluation. Void areas on walls and floors can also be missed without adequate lighting. Proper lighting assists by providing needed contrast and color for photography, especially if indoors and a flash is not utilized for various reasons. Fig. 9.3.13 provides an example of LED floodlights that can be brought to a scene.

FLASH PHOTOGRAPHY OF BLOODSTAINS

A problem often encountered in photographing bloodstains is that the flash unit is attached to the camera's hot-shoe, causing blood to reflect light from the flash. If a flash is attached to a camera's hot-shoe while photographing a bloodstain, the axis of reflected light is directly returned toward the camera. This can fool the camera's internal light meter, resulting in an underexposed image. Another issue with photographing bloodstain patterns and stains with a flash mounted on the camera's hot-shoe is that since blood is a liquid, it can reflect light, with a resulting loss or diminishment of detail, as seen in Fig. 9.3.14. Instead of placing the flash on the camera's hot-shoe, the photographer should attach it to a PC cord (sync cord) and hold the flash at an angle to the bloodstain being photographed while the camera's film plane (digital sensor) is parallel to the bloodstain. A flash angle of around 45° often works well, but the distance of the flash to the bloodstain is also a factor. The photographer should experiment with the angle and distance of the flash to the pattern being photographed for maximum capture of detail. Having the flash off the hot-shoe and angled toward the stain or pattern allows the reflection of light to be directed other than directly back into the camera's internal light meter. Fig. 9.3.15 is an example of the same transfer stain photographed with the flash attached to a PC cord and held at a near 45° angle to the bloodstain. Notice that the pattern contains more detail and is not washed out as in Fig. 9.3.14.

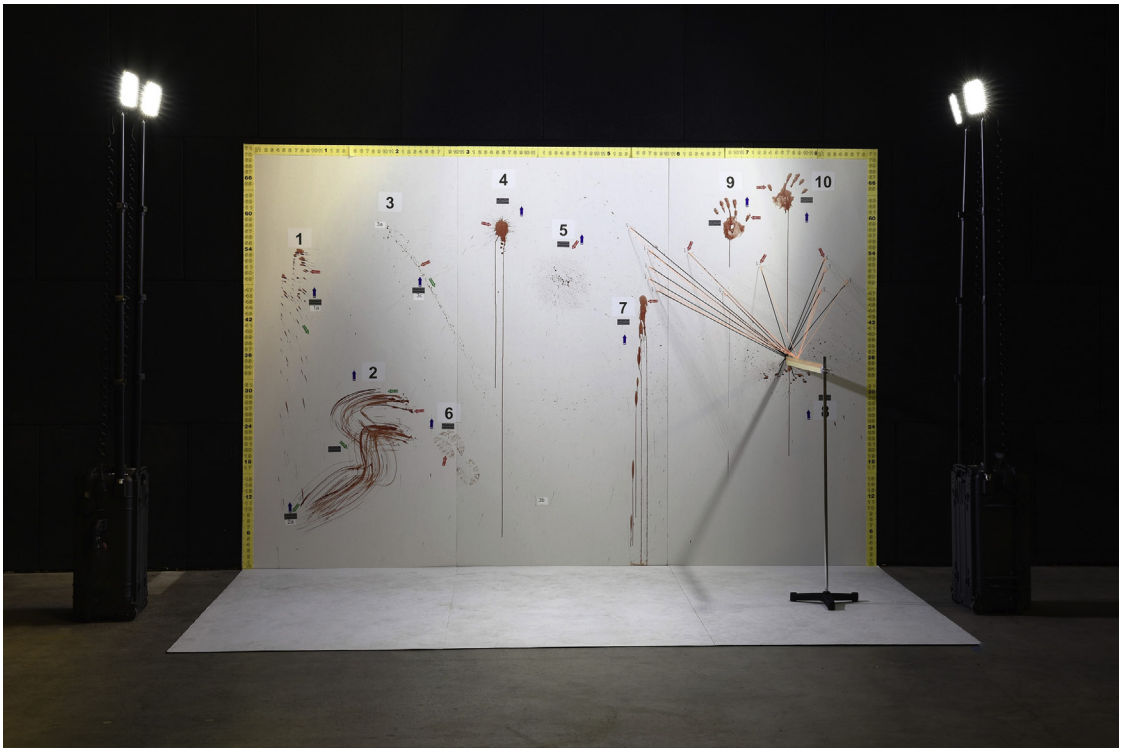


FIGURE 9.3.13
LED floodlights used to illuminate a wall with bloodstain patterns and stains.



FIGURE 9.3.14
A photograph of a transfer stain with a flash mounted on the camera's hot-shoe. Note how a large portion of the stain's detail is washed out due to the reflection of light from its surface.



FIGURE 9.3.15
A photograph of the same transfer stain shown in Fig. 9.3.14. The flash is attached to a PC cord and angled to the stain at an approximate 45°. Note that the detail is preserved and not washed out as in Fig. 9.3.14.

CHEMILUMINESCENCE AND THE PHOTOGRAPHIC MERGE METHOD

Luminol and other chemical reagents are used to search for and locate latent blood. When these chemical reagents come into contact with blood, a light reaction occurs called chemiluminescence. Photographing chemiluminescence from luminol, for example, is difficult because it emits a light of blue color which does not last very long and can only be seen in complete darkness. Another issue with photographing chemiluminescence is the documentation of adjacent objects in a darkened scene in their natural colors.

The following steps and settings can be applied when photographing a light reaction to blood with a chemical reagent like luminol: these following are general settings and may vary depending on the camera setup:

- After locating chemiluminescence and collecting samples for DNA, place the camera on a tripod close to the chemical light reaction.
- Set the ISO to 800.
- Set the aperture between f/5.6 and f/11.
- Set the shutter speed between 15 and 45 s depending on aperture setting.
- Use manual focus.
- Turn off the flash.
- Darken the room.
- Apply the chemical reagent.
- Depress the shutter button with a shutter-release cable or a similar control.
- Examine the picture on the viewfinder.
- Without moving the camera or changing the lens settings, take another picture with a flash.
- Merge both photographs into a single image.

After merging the photographs, a single image will show not only the chemiluminescence, but also the surrounding objects and references in their true colors. Fig. 9.3.16 is a photograph of a chemiluminescent reaction to blood on a mat while in darkness. Fig. 9.3.17 is a flash photograph of the mat where the chemical reaction was observed. Fig. 9.3.18 illustrates a merging of the two photographs. This method is easy to achieve and provides true colors of objects near the chemiluminescence.

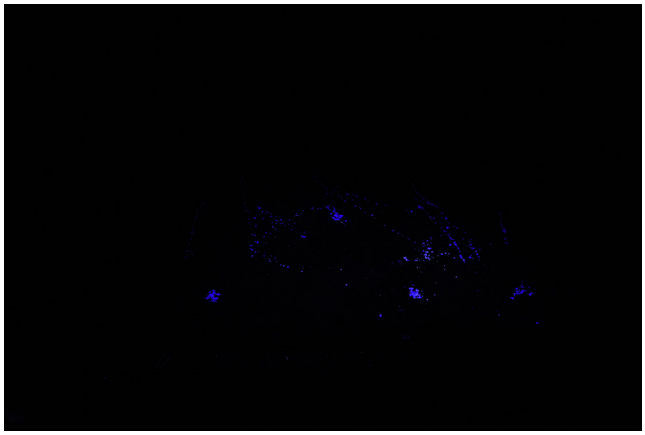


FIGURE 9.3.16
A photograph of a chemiluminescent reaction to blood on a mat photographed in complete darkness. The photograph was created with an extended exposure interval without a flash.



FIGURE 9.3.17
A photograph of the mat where the chemiluminescent reaction was noted (Fig. 9.3.16). The location of the camera and the lens settings did not change between photographs. This photograph was taken with a flash.

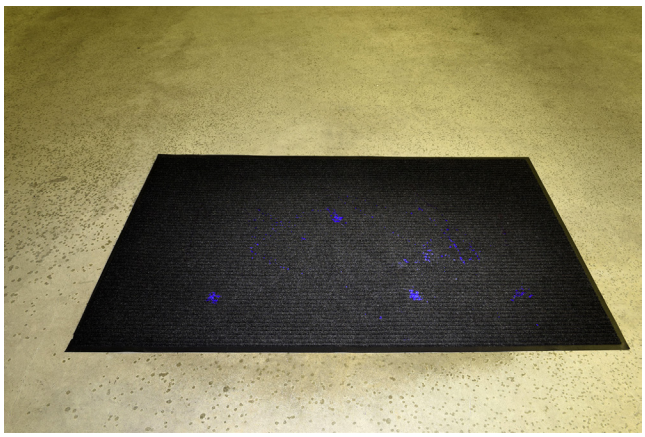


FIGURE 9.3.18
The final product of a photographic merge. Figs. 9.3.16 and 9.3.17 were merged to create an image showing chemiluminescence on a mat with its true colors.

Further Reading

Wolson, T.L., 1995. Documentation of bloodstain pattern evidence. Journal of Forensic Identification 45 (4).

SUBCHAPTER 9.4

Drones

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INTRODUCTION

The Drone Age has arrived.

After centuries of experimentation and decades of refinement, unmanned robotic systems, commonly known as *drones*, have surfaced in literally every corner of the earth. These "moving robots" will revolutionize the way work is approached in every discipline, for better or worse. Crime scene investigation is no exception.

Recreational drones, predominantly those that fly, have exploded in popularity in recent years. Unmanned aerial vehicles (UAVs) are widely available, and range from high-end, high-performance systems produced by specialized manufacturers to low-cost, decent-performing systems on sale at local hobby shops. Either can be used by photographers to capture remarkable images of crime and accident scenes. While not as widely used, unmanned ground and maritime drones can also be invaluable to crime scene investigators.

THE IMPACT OF DRONE TECHNOLOGY

Drones extend the reach of the photographer. They facilitate an exciting expansion of the range and detail of crime and accident scene photography.

Consider the introduction of a K9 team into a police department. A dog can extend the reach of a police officer during a foot pursuit and the detection of narcotics during a premise search. K9s are force multipliers—they provide specialty support to improve the overall performance of a police department without altering fundamental responsibilities and procedures. However, they require a lot of training, time, and attention from the handler. The costs can add up. Adding drones to crime scene investigation teams presents similar dynamics.

What doesn't change:

Remote photography adheres to the basic principles of crime (Fig. 9.4.1) and accident scene photography (Fig. 9.4.2).



FIGURE 9.4.1
Aeryon Sky Ranger extends the reach of the photographer providing new perspectives of crime scenes. Designed to military and government specifications.
Photo courtesy of Aeryon Labs, Inc.

Remote photography uses the same functionality as traditional photography. Camera positioning, settings, and shots are managed through remotely located monitors and controls.
Remote photography does not require new camera equipment. However, powerful and innovative new drone-ready cameras are available.

What does change:

Drones require a new skill set. Operators need training in navigation, repair and maintenance, and frequent, ongoing practice. Normally, a second person is needed, as it is difficult to photograph and operate the system simultaneously.
Drones are new equipment. Selection and deployment of systems is time consuming and market information is often sketchy and even contradictory.
Drones are regulated by unfamiliar agencies, must adhere to privacy and search laws, and require certification. Drones present new risks. Cameras don't have the capacity to fly into people or lakes, but drones do.

Value of Unmanned Systems

The fundamental value of unmanned systems in crime scene and accident investigations is their ability to access points of interest in virtually any environment with imaging equipment (including cameras), analytical sensors, and even evidence collection tools (Fig. 9.4.3). While their full capabilities are beyond the scope of this chapter, it is important to understand that unmanned systems are flexible enough to perform a myriad of tasks.



FIGURE 9.4.2
Aeryon Sky Ranger over an accident.
Photos courtesy of Aeryon Labs, Inc.



FIGURE 9.4.3
3DR Solo, powered by twin 1 GHz computers, the world's first smart drone.
Photo courtesy of 3D Robotics, Inc.

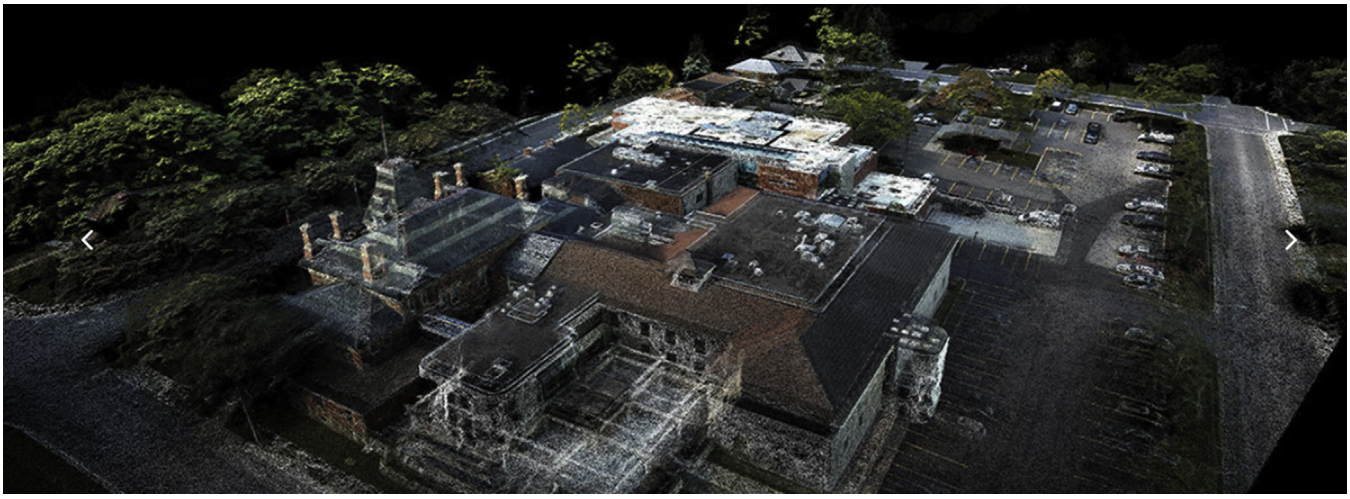


FIGURE 9.4.4
Aeryon Sky Ranger mapping.
Photo courtesy of Aeryon Labs, Inc.

Access: Unmanned systems can access locations that were previously much more difficult to reach. Aerial systems can access areas such as canyons, cliffs, and remote locales more quickly than traditional means. Quick and easy access allows for planning, preparation, and completion of a mission in a more successful and timely manner. Such access also allows significantly better documentation of scenes that are too remote for typical methods. Maritime systems provide new and improved opportunities to document and collect evidence in aquatic environments. They offer ready access to areas too dangerous or inaccessible to divers. Ground vehicles are also useful in situations too dangerous for investigators. Ground vehicles are often used to document and mitigate suspected incendiary or explosive devices. Unmanned systems protect investigators from a variety of risks and hazards inherent to incident scenes.

Perspective: Obtaining photographs from a "bird's eye" perspective has always proved to be a challenge when documenting a crime or collision scene. Prior to technologies such as unmanned aerial systems (UAS), investigators attached their cameras to a long extension handle or used bucket trucks to take overhead photographs, and in some cases used expensive manned aircraft. The use of UAS eliminates the need for such practices and offers a new perspective of the scene. UAS can easily take photographs from directly above the scene. Additionally, photographs can be taken from different elevations and perspectives providing views not previously available (Fig. 9.4.4).

Preservation: The use of unmanned systems allows crime scene imaging to be conducted before the cross contamination by investigators, accessing the scene and travel paths used by victims and perpetrators, compromises evidence. Unmanned maritime systems (UMS) provide a unique opportunity to document an underwater scene without jeopardizing human life. The systems can capture photographs and video documentation, and even collect physical evidence.

Safety: Use of UAS, UGS, and UMS can significantly mitigate or completely eliminate the hazards inherent to a variety of locations and circumstances. Unmanned systems facilitate access to scenes in precarious locations including steep hillsides, confined spaces, underwater environments, hazardous material spills (Fig. 9.4.5), and even in the line of fire at active crime scenes without direct physical presence or risk to public safety personnel.

Collaboration: Preliminary photographs and video taken from the unmanned craft can be shared with personnel whose on-scene presence is not essential. Supervisors and others associated with the investigation, including "experts" and stakeholders in other cities, can view the scene without being there by utilizing media transfer protocols and secure network technologies.

Productivity: In many cases, unmanned systems can reach a scene, acquire information and evidence, and return to investigators significantly faster and at less expense than traditional methods of access and acquisition. The use of UAS in a wide search for crime scenes and evidence can cover territory and visualize the subject more efficiently than dozens of searchers spending hundreds of hours on foot.



FIGURE 9.4.5
iRobot 510 PackBot. Unmanned systems give the photographer access to dangerous and contaminated scenes.
Photo courtesy of iRobot.

Cost Efficiency: While the initial cost of a quality unmanned system can be significant, such expense can offer a significant return on investment. Aerial systems provide a more economical alternative to collecting photographs or video than traditional means, such as manned aircraft or scuba divers.

DESIGN AND FUNCTIONALITY

Unmanned systems are designed to function in defined environments. An aerial drone operates in the air while a remotely operated subsurface vehicle operates underwater. While these two vehicles reside in very different environments, they share many design and function features. Likewise, a wallet-sized quadcopter (2″ diameter) and an MQ-9 Reaper (66-foot wingspan) are very different aerial vehicles. Yet, they too operate in the same environment (airspace) and share many design features and functionality.

While terminology and classification names vary between industries and users, unmanned systems have quite a bit in common. This section explores the components that comprise what is commonly known as an unmanned system.

Vehicle

When asked to describe an unmanned system, most people describe a police bomb squad robot, a child's remote control racing boat, or a military drone used in combat. These are the crafts, or *vehicles*, that do what they are built to do, in the environment for which they are designed. They are what most people *see*, or at least what attracts their attention.

The most popular term for an unmanned plane or helicopter (aside from the catch-all phrase *drone*) is *unmanned aerial vehicle*, or *UAV*. Similarly, albeit less widely used, are the terms *unmanned ground vehicle* (*UGV*) and *unmanned maritime vehicle* (*UMV*). An increasing number of crossover platforms are emerging, such as aerial systems that can also land and operate on water surfaces.



FIGURE 9.4.6
iRobot 510 PackBot. Unmanned systems give the photographer access to dangerous and contaminated scenes.
Photo courtesy of iRobot.



FIGURE 9.4.7
Platypus unmanned marine vehicles. They are robotic airboats that can go out on a lake, river, or area of coastal water and achieve monitoring objectives.
Photo courtesy of Platypus LLC.

Unmanned ground vehicles (***UGV***) are typically motor-propelled crafts that move on wheels or tracks. These vehicles generally operate in ground environments. Remote control *hobby cars* are typically used in homes, backyards, and pedestrian surfaces. Police *bomb and tactical robots* navigate in indoor or outdoor public environments; some even climb steps (Fig. 9.4.6). *Driverless cars* are cruising city streets. *Telepresence robots* are providing bedside monitoring and companionship in hospitals.

Unmanned maritime vehicles (***UMV***) are generally built for either surface (*unmanned surface vehicles*) (Fig. 9.4.7), or sub-surface (*unmanned underwater vehicle*) functionality. Surface craft can range from hobby-grade vessels used in backyard pools to military vessels that pursue pirates. *Remotely operated vehicles* (ROV) operate underwater through tethered power and telecom cables. *Unmanned submarines* can perform functions such as ocean floor oil leak repairs and mine sweeping.

Unmanned aerial vehicles (***UAV***) fly in the air. *Fixed wing* vehicles are similar to manned airplanes, and typically use a propeller for propulsion and fixed wings and a tail rudders for navigation. *Rotary wing* vehicles are similar to manned helicopters, using one or more rotors for propulsion and navigation. Rotary wing craft are further characterized by their number of rotors. A craft using two or more rotors is called *multi-rotor*. The most popular consumer multi-rotor uses four rotors, and is often referred to as a *quadcopter*. The third type of UAV is *lighter than air*, commonly known as balloons or dirigibles.

A fourth type is an *unmanned space system* (*USS*). It's use is beyond the earth's atmosphere and beyond the scope of this chapter.

Unmanned vehicles have two primary sections: *platforms* and *payloads*.

Platforms

All unmanned systems rely on similar components, collectively referred to as their *platform*, to navigate within their native environments.

Frame: The frame provides support for all components and payloads. A *shell* is typically attached to the frame to protect the components. This is especially important in waterborne unmanned systems.

Camera Mount: Most drone frames accommodate cameras; usually a simple mounting bracket or a *gimbal*, which is a support system that facilitates XYZ axis movement of a camera or other imaging device attached to it. A gimbal keeps the imaging device at a constant angle, regardless of drone movement.

Power: Most drones use electricity to power both the motor and the onboard electronics. The total weight of the drone and the power used by motors and electronics will determine battery life. Typically, lithium polymer (LiPo) batteries can sustain drone operations for 15–30 min. Limited battery life, charging stations, extra batteries, and the amount of time to recharge must all be considered. Models that use combustible gasoline engines do not require batteries for propulsion, but batteries are still needed to operate the electronics.

Communications: Most unmanned systems include an onboard receiver for instructions sent from the ground controller. Increasingly, models include WiFi transmitters that send photos, video, and other data to ground units. Receivers and transmitters also require antennae.

Navigation Controller: The "brain" of an unmanned system is its controller, which is a combination of hardware and software. In UAVs, the controller initiates instructions regarding vehicle guidance, GPS positioning, gimbal and payload interfacing, and more. Autopilot features such as stable hovering and "return to home" are also available for some vehicles.

Payloads

The *payload* is the cargo and other nontransport, nonnavigational elements attached to the platform. The payload may include cargo (being delivered or retrieved), camera/imaging and multispectral analysis equipment (infrared, thermal imaging, lasers, photogrammetry, etc.) (Fig. 9.4.8), manipulators (pincers/grippers, arms, etc.), weapons (in military crafts), sensors for analyzing objects and environment, and even microphones. While the platform enables the unmanned vehicle to reach a destination, the payload facilitates the fulfillment of a function or mission at the destination(s).

The most common type of payload on consumer and commercial unmanned vehicles is camera and imaging systems. There are three general options:

Integrated: Many manufacturers offer models with cameras built into the platform. These tend to be easy to use because they provide the operator with more control. The resolution is often low with these cameras, however, that is improving.



FIGURE 9.4.8
Aerylon Sky Ranger, a vertical takeoff and landing (VTOL) unmanned aerial System. Designed to military and government specifications.
Photo courtesy of Aeryon Labs, Inc.



FIGURE 9.4.9
Falcon Hover, with a Day/Night Live Video and a Gimbal.
Photo courtesy of Falcon Unmanned.

Action: Most platforms have mounts or gimbals that easily accommodate third-party *action cameras*, such as GoPro. Action cameras can produce fairly high-quality photographs and video. Equally important, they are extremely lightweight. Currently, however, users have limited control over camera functions.

Custom: Most platforms can accommodate consumer and professional cameras ranging from modest point-and-shoot models to sophisticated digital SLR cameras, even with high-powered lenses. These are best attached to gimbals to assure stability and range of motion.

Cameras are most popular on aerial vehicles (Fig. 9.4.9), although they are increasingly adapted to ground vehicles. Commercial and professional applications typically use camera equipment in all environments. For the foreseeable future, aerial drones will be more widely used than ground or maritime units by crime and accident scene photographers.

Unmanned systems that include onboard WiFi can stream video to ground controllers, enabling the operator to see what the camera sees. This technique, called *First Person View* (*FPV*), provides the photographer with a similar image as the LCD screen that is located on a digital camera.

As with any platform or payload component, weight is the driving variable. On drones, this is known as *payload capacity*. More weight means, more power is needed. Heavier motors and batteries are needed to generate more power, but they also add to the weight, requiring even *more* power. Multi-rotor UAVs also help with higher payload weight—more rotors translates into more lift power. A crime scene photographer who requires heavy photography equipment should be prepared to pay for heavy-duty platforms.

Command and Control

Unmanned vehicles can function in almost any environment. However, they still require control by one or more individuals, regardless of the location of those individuals. Control is accomplished in one of three ways:

Remote Control, aka ***Radio Control***, aka ***R/C***: This method is by far the most popular, especially on consumer and lower-end commercial unmanned systems. With R/C, an operator controls all the movement of the vehicle, usually through a handheld controller used to convey navigational and functional instructions.

Autonomous: Some unmanned vehicles may be "preprogrammed" with flight instructions, eliminating the need for active, hands-on piloting.

Semi-Autonomous: Many systems, even modestly priced models, have some autonomous features, such as an iPad with a Google Earth overlay allowing an operator to trace out a navigation path that is converted by the controller to a series of paths to GPS waypoints.



FIGURE 9.4.10
3DR Solo controller.
Photo courtesy of 3D Robotics, Inc.

Regardless of method, ground control units can typically override autonomous control and "take control" of an unmanned vehicle. The controllers, or *transmitters*, for most small unmanned systems are handheld devices with joystick controllers, switches, and an antenna. Many models also feature a small monitor that receives a video stream and pictures from the unmanned vehicle (Fig. 9.4.10).

Unmanned Systems

The term *system* is generally used to describe the combination of all elements described above, including:

The unmanned vehicle, including the platform and its payload.
The trained pilot, and in certain situations, at least one additional operator.
The ground control transmitter.
With some midsize models, a ground launcher and/or ground recovery equipment.
Communication links for flight control and conveyance of data and images.

These components collectively create the unmanned system. This applies to *UGS*, *UMS*, and *UAS*.

Performance

Unmanned systems are available in all shapes, sizes, and costs. Consumer grade, typically used for recreational purposes, are remarkably inexpensive. Commercial grade drones are considerably more flexible and reliable, but come at a higher price. Crime scene investigators can derive benefits from both consumer grade and commercial grade systems, but to generate court-quality evidence, the use of high-quality systems is highly recommended.

Limitations

Unmanned systems are amazing tools, but they have limitations:

They require training and experience to operate in mission critical applications.
They do not yet self-navigate well around indoor or outdoor obstacles.
They can be disrupted: an article of clothing lying on the floor can disable some UGS tactical models.
Weather or water conditions can disrupt or prevent drone operations.
Vibration from the frame, motor, and environmental conditions can degrade photo quality.
Wireless communications links have distance limitations and are subject to technical disruptions.
Batteries typically support operations of 30 min or less for most unmanned systems.

USES

Law enforcement and crime scene investigation agencies have been slow to adopt unmanned systems for several reasons. These include community opposition due to privacy concerns, tight budgets, lack of cost–efficiency studies, and wariness of new technology. That is unfortunate because the integration of unmanned systems into the criminal justice system will benefit crime and accident scene investigation directly and indirectly.

Traditional Crime and Accident Scene Photography, Imaging, and Mapping

By far, the most common use of unmanned systems will be traditional photography, video, imaging, and mapping of crime or accident scenes that are secured (no longer active) (Fig. 9.4.11). The efficiencies of drones are considerable and, in some cases, unexpected. Mesa County (CO) Sheriff's Office was among the first US law enforcement agencies to received FAA certification to operate an unmanned aerial system. Originally, the county believed the primary mission of their two UAS was for search and rescue operations. They quickly found that their predominant value was in crime and accident scene reconstruction. For example, their UAS cut the average time for highway closures due to accidents from 3 h to just 1 h (Lewis, 2014).

Underwater Crime and Accident Scenes

The collection of evidence in underwater scenes is increasingly recognized as something more than just a salvage operation. However, that environment presents unique challenges such as low visibility and displacement of evidence by even slight water disturbance. Unmanned maritime systems such as autonomous underwater vehicles (AUV) and remotely operated vehicles (ROV) facilitate effective remote underwater photography (Fig. 9.4.12). Investigators who are not divers can explore and photograph the underwater scene while stationed on a boat, bridge, or even the other side of the country.

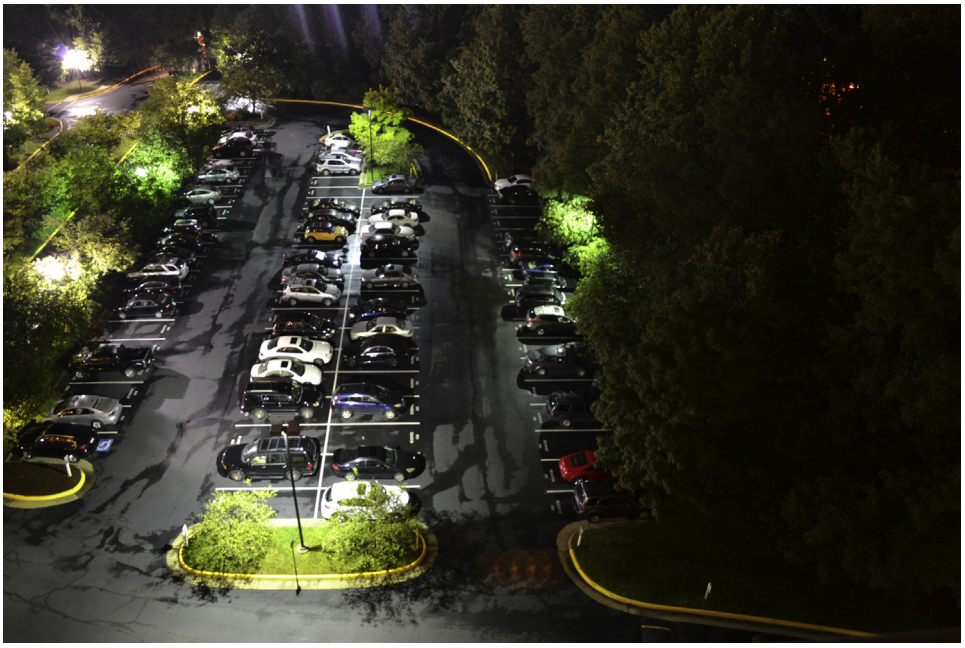


FIGURE 9.4.11
Aerial view of a parking lot.
Photo courtesy of GWU MFS student M. Scott.



FIGURE 9.4.12
Underwater SeaBotix Drones.
Photo courtesy of Teledyne SeaBotix Inc.

Detection of Crime and Accident Scenes

When paired with unmanned systems, cameras can do more than photograph crime scenes—they can help find them. Researchers and public safety officials are collaborating at the Forensic Anthropology Center (aka "body farm") operated by Texas State University to detect corpses and body parts using UAS. Near Infrared technology (NIR) can detect corpses above and below ground. "As a corpse decays it releases carbon and nitrogen into the soil, which initially kills nearby vegetation. Later, it becomes a fertilizer that produces increased vegetation. In both circumstances, NIR can detect the changes for up to two years, even if the body had been subsequently removed (Mutnick, 2015)." In situations like this, it may be possible for UAS to not only find the crime scene, but also locate and map the crime trail and take photographs before the landscape is disturbed by searchers.

Active Crime and Accident Scenes

Unmanned systems are effective at documenting active scenes. The collection of information such as photographs, videos, and air samples; locating suspects or vehicles; and documenting weather conditions can prove invaluable to an investigation. Unmanned systems have been used in tactical situations to provide live video of the activity in a hostage situation. Unmanned ground systems are commonly used to photograph, X-ray, detonate, examine, and collect suspicious devices or bombs.

Unmanned systems can be a valuable tool in a HAZMAT situation. A remotely-deployed system streaming live video can help determine if victim rescue is necessary, take air samples to ensure first responder safety, and document the entire scene without endangering lives. A combination of both aerial and ground systems can provide different perspectives of the scene, providing real-time photographs that contribute to the understanding of a crime or accident.

Third-Party Evidence Submissions

Photographs and videos taken by bystanders and witnesses are rapidly expanding thanks to smart phones with powerful built-in cameras. These images are often valuable records of crimes in progress or their immediate aftermath. Drones will dramatically increase amateur photography and video of crime and accident scenes. In 2011, an amateur drone photographer taking landscape pictures near Dallas, Texas, noticed red spots in the Trinity River near a meat processing plant. He passed the photos to the Coast Guard and within a few months state environmental officials searched the premises and discovered that pig blood was being piped directly into the river (Keneally, 2012).

While such images are not "official" documentation for evidentiary purposes, they often provide valuable documentation of the scene. Comparison between official and unofficial images may reveal suspects, witnesses, and items altered or removed before officers and investigators arrive. Contamination of evidence by nonprofessional access is a concern, but the taking of photographs remotely does not inherently disturb the integrity of the scene. In cases where the evidence is not immediately accessible or where the person who acquires the images is not willing to cooperate, the drone and camera may be confiscated by police.

LAWS, REGULATIONS, AND OVERSIGHT

In years past, remote control vehicles were either in the hands of hobbyists or the military. They did not breach private property or otherwise impose on daily life. That has changed dramatically. Today, unmanned system regulation has become a contentious topic in the halls of Congress, in every statehouse in the nation, and even in the local town hall. Anyone using drones for crime and accident investigation must not only be aware of regulation, but must diligently follow all new applicable local, county, state, and national laws and ordinances.

Unmanned Systems Regulations

Responsibility for domestic oversight and regulation of unmanned systems technologies is dispersed among a growing number of agencies, task forces, and all levels of government.

Aerial drone operation in the National Airspace System (NAS) has generated the most regulatory attention far and away. The Federal Aviation Administration (FAA) has jurisdiction over all domestic airspace, which starts just above ground level and extends to 60,000 feet above ground level (AGL). Most recreational and professional UAS currently are limited to operations up to 400 feet AGL, which falls within Class G airspace (the lowest to the ground).

A patchwork of FAA mandates and regulations were somewhat consolidated with the FAA Modernization and Reform Act of 2012 (Public Law 112-95) (FAA). Among its many provisions, this law mandated safe integration of commercial UAS into the NAS by September, 2015, a deadline that was missed by the FAA. However, public safety agencies, which include crime scene investigation units, can conduct operations with either a Certificate of Authorization (COA) or a Section 333 Exemption. To obtain either, an organization or agency must demonstrate to the FAA that their equipment is airworthy, personnel are certified, and certain other criteria are met.

The US. Coast Guard has authority over many aspects of unmanned maritime vehicles, including provisions that fall under collision regulations (COLREGS). However, states and even local government bodies also have jurisdiction on certain waterways and bodies of water. UMS have received little attention to this point, so there are few regulations specific to surface or subsurface maritime systems. That will no doubt change as more recreational and commercial craft are launched on and under rivers, lakes, and oceans.

State and federal motor vehicle laws appear to be the primary regulatory instrument of unmanned ground systems. Most focus on vehicle and roadway safety. Most UGS are designed for off-road applications, which is predominantly unregulated. However, as unmanned technology permeates the workplace, agencies such as the Occupational Safety and Health Administration (OSHA) will soon follow.

Privacy Laws

When industry officials turned their attention to the domestic UAS market, there was an immediate groundswell of opposition from privacy advocates. News stories had extolled the tremendous intelligence, surveillance, and reconnaissance (ISR) capabilities of drones in the Gulf War. This was welcomed on the battlefield, but not at home. Protestors emerged in cities across the country. Elected officials quickly recognized the threat to privacy (and the public pressure). Even Congress concluded "the full-scale introduction of drones into US skies will inevitably generate a host of legal issues." The report predicts privacy advocates will claim Fourth Amendment violations, news agencies will claim First Amendment violations, and paparazzi face frequent legal scrutiny for actionable trespass (Dolan and Thompson, 2013).

At this time, at least 14 states have passed drone privacy laws that dramatically restrict the circumstances under which law enforcement can use unmanned systems (Interactive Privacy Map). Most require search warrants, maintenance of detailed operational logs, and the destruction of all photographs and videos obtained by drones that are not part of an ongoing investigation. In addition, a growing number of local governments are passing drone-restrictive ordinances. Not only will that trend continue, it will accelerate and expand.

Crime scene photographers must closely monitor these emerging laws and regulations, many of which will impact operational procedure. For example, whereas search warrants are not typically needed to conduct a crime scene investigation, they may be needed if an aerial drone is used, even if just to take photographs. Moreover, the handling of photographic evidence may be subject to new drone privacy laws.

Professional Associations

Unmanned systems technology presents a unique and dramatic opportunity to advance the efficiency and effectiveness of crime scene investigation. The technology also presents new responsibilities and falls under new oversight by the FAA and other agencies. These new challenges are regulatory in nature and do not yet require specialized training or credentials other than basic FAA pilot training. They certainly do not address protocols or training specific to crime scene investigation.

There are more than 150 national and international professional associations representing the various segments of public safety-related professions. Many of these offer professional accreditation on a wide range of topics. For example, the International Association for Identification (IAI) uses this textbook (*Crime Scene Photography*) for its Crime Scene and Forensic Photography certification. These organizations significantly contribute to professional training and conduct. At this point, none of the public safety organizations surveyed offer courses or certification related to the use of unmanned systems in crime and accident scene investigation.

Several public safety professional organizations have taken public positions on the use of drones within their discipline. The International Association of Chiefs of Police (IACP) has issued a "Recommended Guidelines for the use of Unmanned Aircraft." These include recommendations such as "images should not be retained unless relevant to a crime" and "drone use should be subject to tracking and audits, with accountability for misuse (Recommended Guidelines for the use of Unmanned Aircraft, 2012)."

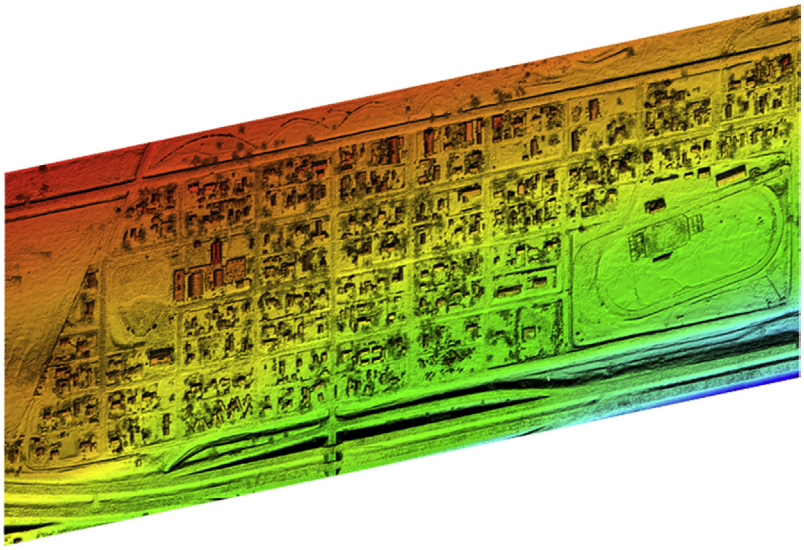


FIGURE 9.4.13
Falcon Map, a high-resolution georectified orthophoto. Mapping capabilities of the Falcon.
Photo courtesy of Falcon Unmanned.

MISSIONS

Crime and accident searches and documentation using unmanned systems provide accurate results that replicate those of traditional methods (Fig. 9.4.13). The value of unmanned systems will depend on the quality of the equipment, the skill of the operator and photographer, and the degree of support from and integration in the agencies that operate them.

Preliminaries

Most experienced photographers will quickly grasp the value of unmanned systems and will quickly adapt to the nuances of remote photography. However, they must also know how to select, operate, and maintain unmanned systems. That will be time consuming, especially if the photographer does not have any experience with remote control systems. At minimum, decisions must be made regarding personnel, equipment, training, and policies.

Personnel: A limited contingent of personnel should be operating an agency's unmanned systems for two reasons. First, unmanned systems are rugged by design; however, components are often delicate and require consistent maintenance and regular inspection. The more operators who use the system, the greater the likelihood of lapses in this regard, and the more difficult it is to hold users accountable for the lapses. Second, the cost of training personnel can be significant. Additionally, personnel must have regular and frequent opportunities to use the systems. Otherwise, their skills will be deficient, increasing risk to the systems and their missions.

Equipment: Careful planning is necessary to specify and acquire unmanned systems that meet an agency's needs. Primary consideration should be given to camera capabilities. Most low-end unmanned systems have integrated or easily mounted action cameras to capture still images and video. However, the video is standard quality and the images are around 1 megapixel, neither being adequate to meet evidentiary standards. Higher-grade systems provide 4K video and 12 to 16 megapixel still images, comparable to DSLR cameras commonly used by crime scene investigators. Or, unmanned systems that accommodate DSLR cameras can be specified. All collateral equipment and supplies, such as spare batteries and chargers, must be identified and acquired.

Training and Certifications: Personnel assigned to systems operation must be properly trained. Some unmanned system companies provide proprietary training on the use and operation of their systems. Additionally, there are private companies that provide training and "certification" on the operation of unmanned systems. Training should include FAA and other regulations, Federal and state laws, local ordinances, and departmental polices or forensic standards on the operation of unmanned systems. Advanced training in photography should also be provided so the operator/investigator understands and can achieve the expected results. The operator/investigator should be required to demonstrate proficiency and competency in all phases of system operation prior to assignment to perform case work.

Policies and Procedures: Strong and effective policies and procedures are essential to insure high-quality unmanned systems support. Indeed, a growing number of laws, regulations, and insurance companies mandate that agencies have policies and procedures in place. These must clearly define operational and procedural processes and requirements, but be flexible enough to allow system use for any lawful purpose.

Deployment

Unmanned systems should respond in a manner consistent with departmental policy for any other incident response.

Response: Proper preparation is essential to ensure optimization of system performance and mission functionality at a crime or accident scene. Since battery life is limited, operators must have several, fully-charged batteries for all unmanned system components. All equipment should be safely packed and stored in padded boxes that secure all components. This is especially important for delicate components such as rotor blades.

Arrival: Upon arrival at the scene, the operator/investigator should be briefed as to the scope and size of the scene, as well as any other conditions and circumstances that might affect system operation. If a search warrant has been issued, the photographer must be specifically advised of the scope of the search. Stakeholders should collectively define and agree upon the unmanned system mission.

Survey the Landscape: Once the operator knows the scope of the scene and photo/video objectives, a careful assessment of the environment is crucial. This must include assessment of the environmental and atmospheric features and conditions, assessment of current and predicted weather, lighting conditions, amount of time that will likely be needed to complete the mission, and all hazards such as overhead utility wires. The operator should also clearly identify situations that could potentially be construed as privacy violations.

Select System(s): Ideally, investigators will have more than one unmanned system. For aerial photography, at least one fixed wing and one rotary wing is advisable. Fixed wing UAS are good at long, sweeping motions, which is ideal for mapping fields (Fig. 9.4.13), and entire city blocks. Rotary wing UAS can navigate tight spaces and sharp turns, hover in place, and get much closer to physical evidence.

Pre-Mission Checks: The system to be used should be inspected to ensure that the motors and other operating parts are in working order. On aerial systems, the rotor blades should be inspected for damage to prevent failure that could negatively impact the mission or the scene.

Pre-Mission Walkthrough: Once the operator has assessed the environment and checked equipment, a quick review with the scene commander and other stakeholders is crucial. The operator should confirm the mission objectives, share observations about the environment, describe what equipment will be used and any deficiencies identified during the check, identify any possible privacy or other issues that will require a separate or amended search warrant, and finish with a verbal and/or literal "walkthrough" of how the mission will be conducted.

Notifications: Under certain circumstances, other parties must be notified about certain elements of the mission. Depending on location (and ever-evolving regulations), the closest Air Traffic Control (ATC) tower may need to be notified of times and locations if a UAS will be operating in NAS. A subsurface operation on a river may require the Coast Guard to halt riverboat traffic during the mission.

Operations

Operator training and skill, as well as the quality of the unmanned system(s), strongly influence the effectiveness of crime and accident scene photographs and video taken by drones.

Establishing Shots: Prior to launch, it is advisable to use a handheld camera for establishing shots. In filmmaking, an establishing shot is used to introduce a new scene by showing the setting and perhaps characters: it sets the stage, typically with wide and distant shots. In crime and accident scene photography, they help the photographer plan subsequent shots using drones. They also may be the only photos that preserve the position and condition of subject matter should operator error or mechanical failure cause a drone to crash into the objects it is photographing.

Clear the Field: Prior to launch, all persons within the unmanned system's intended field of operation or path of travel must be notified, not only to stay clear, but to be diligent for possible hazards such as obstructions, other manned or unmanned vehicles in the area, and even curious neighborhood children. Each time a drone is relaunched during the mission, such as after changing batteries, the field must be recleared.

Conduct the Mission: Regardless of type(s) of drones being used to obtain photographs and/or video, the same procedures for handheld or tripod scene documentation apply. A mix of mid-range and close-up photographs should be taken. Since most cameras mounted on aerial drones do not have in-flight zoom capabilities, the craft must be moved close to the objects of interest. When using video, the audio should be turned off. Mid-range and close-up video should be captured as with a still camera

To document an *indoor scene*, start at the established entry point to the scene then proceed through the structure as if you were documenting the scene traditionally. Take overall photographs and video as you work your way through the scene. From there, specific photographs or video can be taken to focus on items of evidence. Finally, close-up photographs should be taken, including a measurement scale if possible. If using a UAS, care should be taken to prevent rotor wash from contaminating or displacing evidence.



FIGURE 9.4.14
WAM (Marine Advanced Research) boat. Unmanned surface maritime systems used for searching below the surface.
Photo courtesy of WAM-V.



FIGURE 9.4.15
Falcon Handheld, a tactical fixed wing aircraft. Falcon handheld UAS being launched.
Photo courtesy of Falcon Unmanned.

Documentation of an *outdoor scene* (Fig. 9.4.14) is similar to indoor procedures, but with more flexibly. There is no ceiling to limit the height of an aerial system (other than mandated flying limitations, which is 400′ AGL for most UAS). The scene should be documented in a systematic order including overall, mid-range and close-up photographs. Specific evidence should also be photographed in place.

Documenting *underwater scenes* (Fig. 9.4.15) poses many unique challenges, beginning with waterproof vehicles. In natural waterways (rivers, lakes, oceans), if the scene is more than a couple feet below the surface lighting equipment will probably be needed. If the scene is at the bottom of a well-maintained swimming pool, natural lighting may be sufficient.

Labeling: Most digital cameras attach metadata to each photograph. This is not visible on the photograph. The metadata that is recorded varies between cameras. Typically it records the camera model, serial number, camera settings used for the photograph, and an internally generated photo number. Some allow for the GPS and even the azimuth of the lens when the photo was taken. Photographers must ensure that all photographs and video taken from drones must be so marked. This is especially true if the same camera is used for handheld, tripod, and unmanned systems shots. State privacy laws may dictate certain reporting and retention rules for any photograph taken by drones.

Logs and Records: Unmanned systems operators must maintain detailed, accurate records of all operations. Log books should document crew members, notes from the walkthrough, a list of equipment that is used, mission numbers, dates and start/stop times, location information (including GPS coordinates), details about how the mission was conducted, results of the mission (such as number of photos and videos taken), and sketches of the scene and mission boundaries.

Post Operations: Upon completion of unmanned systems operations, the photographer should consult the Officer in Charge or others on-scene to ensure all relevant photographs and video have been obtained. If no further work is needed, all stakeholders should be notified that the mission is complete. (This may include ATC notification). The drone should be examined for damage and carefully packed in its case. Photos should be retained according to agency practice and policy.

Risks and Problems

There are risks associated with the use of unmanned systems to photograph crime and accident scenes.

The costs and time necessary to establish and sustain unmanned systems support will probably exceed projections. Research and planning will minimize surprises, the biggest being a five- or six-figure investment in a drone that is inappropriate for crime and accident scene photography.

Image quality and evidence can be compromised by inexperienced operators, equipment malfunctions, and even proper functions (such as the rotor wash created by propellers).

The additional complexity of search warrant preparation may compromise the admissibility of evidence. This is particularly important because (1) most CSI do not obtain a search warrant for every crime scene and (2) state laws are increasingly requiring a search warrant for drone use. Thus, CSIs will possibly need to obtain search warrants more often, causing delays in beginning the crime scene processing.

Insufficiently charged batteries, lack of spare parts, or the lack of a person on scene knowledgeable in making repairs may delay or halt the unmanned system operation.

The complex and rapidly growing body of unmanned systems regulations from federal, state, and local governments increases the risk that crime scene photographers will not be in full compliance. Moreover, crime scene investigators will likely have no previous experience with regulatory agencies such as the FAA.

The unmanned system(s) may not be properly insured, which could prove financially catastrophic, especially to small agencies.

Evidence Processing

Chain of custody and evidentiary considerations must always be addressed in the use of unmanned systems. Photographs and videos are evidence. All departmental Standard Operating Procedures (SOP) and protocols should be followed, as if the images were taken with a standard handheld or tripod-mounted camera.

Departments should already have SOPs for digital images. If not, the Scientific Working Group on Digital Evidence (SWGDE) and Scientific Working Group on Imaging Technologies (SWGIT) can provide guidance on developing proper archival procedures. It should be noted that the Scientific Working Groups have been replaced by the National Institute of Standards and Technology (NIST) Organization of Scientific Areas Committees (OSAC). At the present time, NIST OSAC have not produced any standards, therefore, the SWGDE and SWGIT standards should be followed until replaced with OSAC standards. At minimum, departments should have archival procedures in addition to procedures on formatting or erasing memory cards to avoid intermingling of images from multiple scenes.

Additionally, both SWGDE and SWGIT recommend cameras used to document crimes scenes should be at least 6 megapixels. At this time, most current consumer grade drone systems with FPV do not meet these requirements, nor do they allow the option of ensuring that the minimum necessary compression quality or uncompressed images are taken.

Currently, there is no standard format for documenting crime scenes with video. Video cameras range from standard definition to new 8K ultra-high-definition video. Standard video, which is 480i (480 lines of resolution that has two images interlaced together) is most common in older video and televisions. This old technology is still used in lower consumer grade FPV camera systems. More commonly, FPV camera systems are in the high-definition range, typically 720p. This is better quality video that refreshes from the top down instead of having images interlaced together. High-end camera systems on UAS now have ultra-high-definition, or 4K, cameras. These images are 2160p which provide excellent detail.

Unfortunately, there are no standards in digital video. Each manufacturer can develop their own CODEC, some of which require their own video player. This is troublesome when attempting to share the video among investigators or prosecutors.

Court

The use of unmanned systems—especially UAS—is still very new. Most courts have not been presented with evidence, including photographs, obtained by drones. Many states have passed laws requiring special procedures for drone use by law enforcement, including obtaining search warrants. At this time, few (if any) of these laws have been tested in a courtroom. Similarly, there are very few case laws that can provide guidance at this point.

At minimum, it can be assumed that investigators will be required to authenticate the images or videos captured using the unmanned system. The images presented in court must be accurate and depict the condition observed at the scene, and archived in accordance to departmental policy and accepted forensic practices.

Further Reading

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SUBCHAPTER 9.5

Photographic Documentation of Shooting Incidents

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Law enforcement officers routinely investigate firearm discharges often bearing descriptions of criminal, justified, accidental, negligent, and nontraining related incidents. As these shooting incidents are common occurrences in the United States, law enforcement has a legitimate interest in their analysis. When reported or discovered, law enforcement personnel respond to the scenes of these intentional and unintentional occurrences for the purpose of incident investigation and scene documentation. Chronicling the evidence at a shooting scene frequently involves the use of photography along with other methods to capture the overall, intermediate, or evidence establishing, close-up, and scaled images of bullets, projectiles, defects, cartridge cases, firearms, and firearm components.

The evidence associated with a shooting scene is often only a portion of what the entire scene comprises. While documenting the portions of a scene involving gunfire employs specific techniques, it is important to remember that the whole scene requires proper and meticulous detailing. Personnel responsible for scene documentation must ensure systematic chronicling of the scene before describing the specificity of shooting incident evidence.

DOCUMENTING AND ROADMAPPING BULLET DEFECTS

Proper documentation and processing of shooting scenes is critical to the reconstruction of shooting incidents. The scene may provide evidence supporting the various firearm and ammunition types used, direction of bullet travel, and distances between the shooter and the intended or unintended target(s). From such evidence, a sequence of events may be established.

Appropriate preservation of the scene allows for remote examination and reanalysis when or if obtaining additional evidence. Once fired, the bullet may strike, ricochet or deflect from, perforate, or penetrate a variety of surfaces and objects. Irrespective of the type of defect created, each intermediate and terminal bullet defect located requires thorough documentation.

Each defect should be sketched and photographically documented through a systematic mapping technique. Prior to touching or manipulating the defect, the analyst should chemically test for the presence of copper and lead using the applicable examination method.

The term "roadmapping" was initially employed by the Motorola Company in the 1970s to describe the planning process for an organization's technological capabilities. Toby L. Wolson of the Miami-Dade Police Department's Crime Laboratory used the term to describe a photo documentation method for bloodstain patterns (Wolson, 1997) at crime scenes. Many shooting incident reconstruction analysts use an adaptation of the Wolson procedures when photographically documenting a shooting scene.

Shooting scenes often reveal multiple bullet holes requiring documentation. Overall and mid-range photographs provide a means for understanding where in the scene the bullet defects exist. The close-up photographs, however, afford minimal identification differences between the defects. Roadmapping delivers a useful means for unique defect identification (Fig. 9.5.1).

Because it is a very invasive procedure, roadmapping occurs at the conclusion of all other documentation and evidence collection actions. To commence the process of roadmapping, the investigator or analyst places scale tape vertically and horizontally on the affected surface in the area of the identified bullet defects. The legible scale tape establishes the baseline measurements for locating the defect evidence. After the application of the scale, the next step is to identify each bullet defect individually. Identification can be accomplished using alpha or numeric identifiers. Multiple defects configured in a linear and sequential order can be designated in a manner such as A1, A2, and A3 to support the relationships among defects created by the same bullet. An inexpensive means of accomplishing this denotation process is through the use of Post-it notes. In addition to the alpha or numeric designators, each defect must have a scale reference. An ABFO No. 2 Photomacrographic Scale works well for this purpose. The analyst treats each surface or object containing bullet defects in a similar manner (Figs. 9.5.2 and 9.5.3).

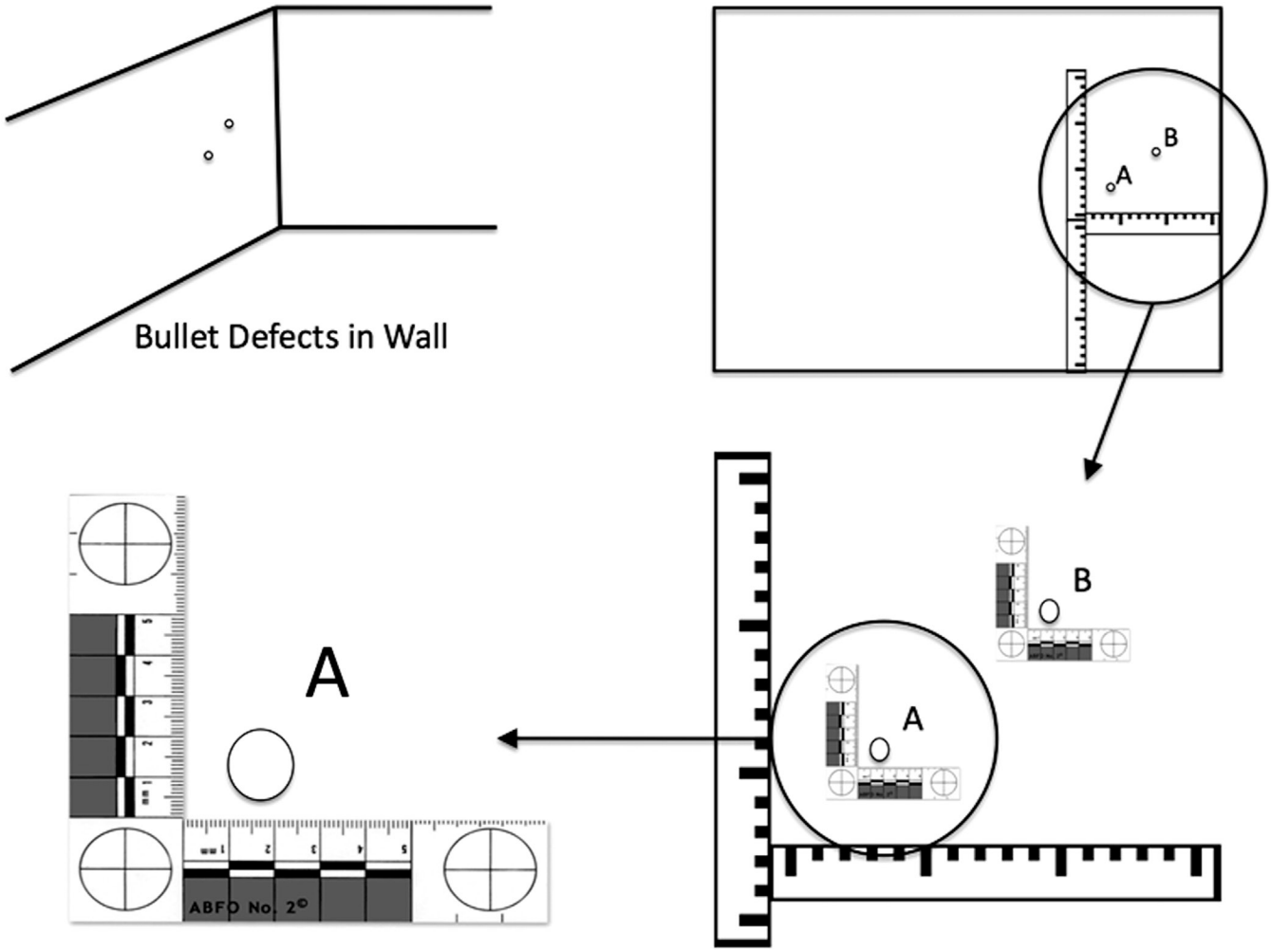


FIGURE 9.5.1
Properly photographed scene through the use of roadmapping takes the viewer from the overall to the specific without getting lost in the photographs.

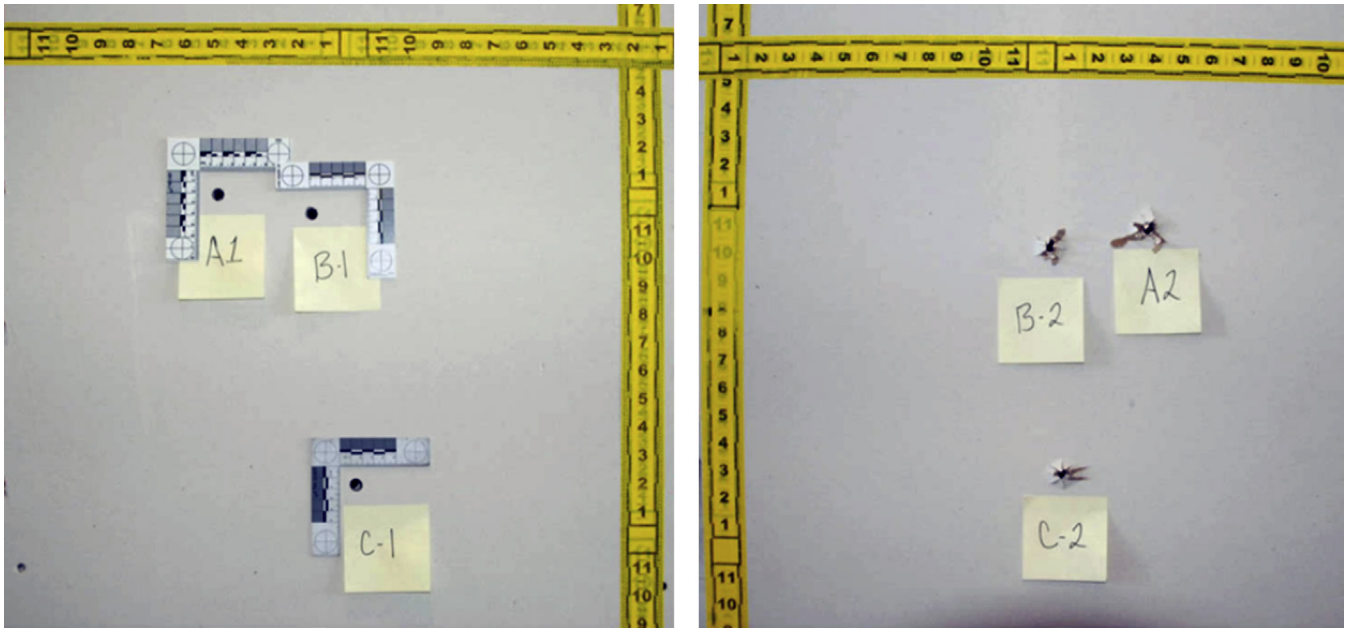


FIGURE 9.5.2
Evidence establishing photograph of three suspect bullet defects on the entrance side and exit of the target. Each defect is identified and scaled.

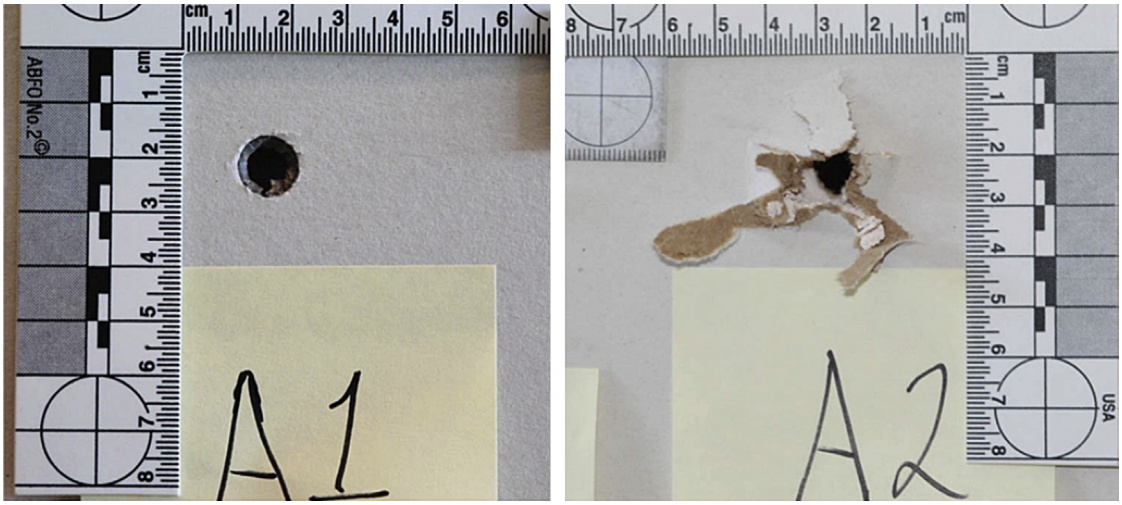


FIGURE 9.5.3
Scaled close-up images of the entrance and exit defects, respectively.



FIGURE 9.5.4
Trajectory equipment and plumb and inclinometer.

TRAJECTORY TOOLS AND THEIR USE

Tools necessary for creating a visible and recognizable trajectory include rods, string, and lasers. Employing the use of tripods can support each of these trajectory devices. To determine trajectory angles, the analyst uses zero-edge protractors, inclinometers, and plumbs (Fig. 9.5.4).

The most common zero-edge protractors are standard 180-degree devices numbered in 10-degree increments and single degree indication markings. The zero edge allows the protractor to rest contiguous with the surface representing the baseline without deviation. Many commercially available protractors come with tabs manufactured on the base of the protractor. The tabs produce an inaccurate degree or angle reading for the analyst as they cause the protractor to sit slightly above the surface. In addition to the 180-degree version, some manufacturers produce a zero-edge 90-degree model for use in restrictive space locations.

Before the production of commercially available rods developed specifically for trajectory analysis, wooden dowels were often utilized. Still employed by many analysts, wooden dowels have the advantage of being very inexpensive and often longer than metal, composite, and fiberglass rods sold by forensic equipment sources. The major disadvantages of the wooden dowels include being naturally warping, bending, and flexing.

Trajectory rods constructed from composite, fiberglass, and metal materials are more expensive than wooden dowels but have the advantage of greater rigidity. String can be useful for producing trajectory demonstratives over short distances. While widely used, stringing is the least useful means of representing a trajectory due to its malleability. Even when the string is secured taut, it continues to stretch and sag resulting in a weak demonstrative of the trajectory. When using string to depict a trajectory line, it is important to establish the trajectory before extending the string from the terminus. Identifying the trajectory with a laser light is one manner of aligning the string between the bullet defect and the point where the dot of the laser light strikes. Another useful method is to attach the end of the string to the rod near the defect and lay the string alongside the rod that indicates the trajectory of the suspected bullet path. The analyst then uses the rod as a guide while extending the string.

Inclinometers are useful for determining the vertical angle of a trajectory as well as establishing the level or plumb of a protractor when measuring angles. A device that is equally useful and specifically designed for indicating plumb is the appropriately named plumb bob. A plumb line is required when showing the vertical angle in a photograph and helpful when measuring the horizontal angle (see Fig. 9.5.4, lower right).

DOCUMENTING BULLET TRAJECTORIES

One of the primary purposes of shooting incident reconstruction is to, as best as practical, identify the paths of all bullets fired during a firearm discharge event. The number of apparent bullet defects in objects or surfaces and gunshot wounds to humans and animals may not provide an accurate representation of a potential minimum or maximum number of shots fired. Bullet defect evidence can be misleading since a single bullet might be responsible for creating more than one wound or defect. Comprehensive analysis requires scanning of all the surfaces and objects for the presence of all possible bullet holes.

Damage, destruction, or alteration of a surface can indicate a bullet defect. However, a fired bullet may or may not be the cause of the defect. An analyst describing a defect as being produced by a bullet is a conclusion best supported by evidence verifying such a deduction. Bullets embedded within a substance or at the end of a trajectory traversing an object can reasonably support a conclusion that the defect is a bullet hole. Positive chemical testing for lead or copper can provide corroboration that a bullet caused the defect. Even when the evidence fails to support conclusions that a bullet was not the cause of the defect, the effort of documenting the defect is not unproductive. All documentation endeavors strengthen the corroboration of complete scene processing (Fig. 9.5.5).

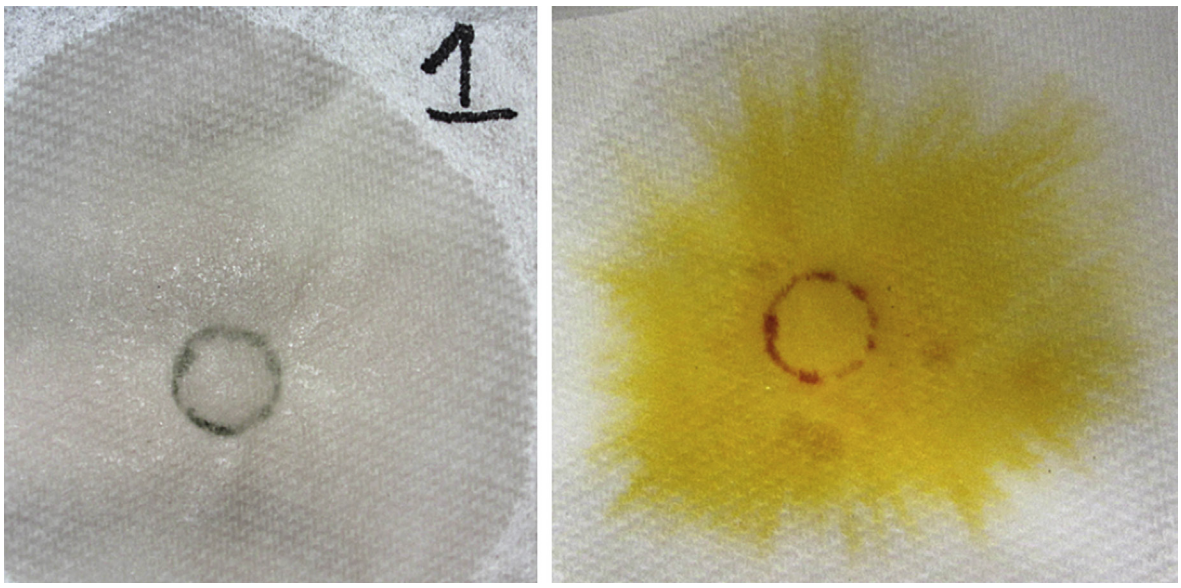


FIGURE 9.5.5
Positive copper and lead testing of suspected bullet defects, respectively.

The most common classifications of bullet defects are perforations and penetrations. The term perforation refers to a projectile that passes through an article. A series of defects classified as perforations always have an entry side and an exit side. When a bullet perforates one or more walls, for example, the analyst would report a single trajectory with single or multiple perforations, respectively. A bullet entering, then exiting human tissue is called a perforating injury. Reporting a defect as a penetration refers to a projectile striking the surface of an object and causing an entry defect but without exiting. The projectile may pass through the surface and embed in a substance or perforate multiple objects before terminating. The latter example demonstrates characteristics of both perforation and penetration. Projectiles that strike the surface of an object and then ricochet or deflect create defects that are neither perforations nor penetrations.

Photographing bullet defects from various angles in the scene is not uncommon practice. Overall photography of this type provides the viewer with an understanding of the scene as a whole and presents a perception of the spatial relationship between evidence items and the scene. After completing the overall photographs of the shooting scene indicating the basic locations of the bullet defects, the evidence establishing, close-up and macro photographs of bullet defects must be acquired while holding the camera lens perpendicular to the surface (Fig. 9.5.6).

Proper subject to lens orientation when photographing bullet defects is essential for documenting the perspective of the defect. While bullets fired relatively perpendicular to the surface, create defects of a similar circular appearance, discharges at acute angles result in defects appearing more elliptical. Appropriately photographed defects can provide an analyst with an ability to measure the long axis and short axis of elliptically shaped defects and calculate its angle by using trigonometry. Moreover, trained analysts can use photographs of circular or elliptically shaped bullet defects to identify the direction of the projectile creating the defect. In addition to calculating the angle of impact or visualizing directionality, photographs of multiple defects in some materials such as glass can afford an analyst with the means for sequencing bullet strike order (Fig. 9.5.7).

After all bullet holes have been classified, documented, and photographed, efforts should be made to determine bullet trajectories. Not every defect created by a bullet in flight offers the capability for an analyst to establish its flight path as several factors contribute to a determination of bullet trajectory. Many bullet defects found at the scene of a shooting allow the analyst to reconstruct the trajectory using conventional trajectory reconstruction tools. Other identified bullet defects require close examination, measuring, and calculation to determine the bullet's trajectory. Occasionally, an analyst discovers defects created by projectiles, bullets, and fragments that assist with an overall examination of the scene, but provide an insufficient or limited definition, quality, and defect points for defining a trajectory. An important factor required by the trajectory analyst is for the bullet to have perforated a minimum of two surfaces or objects along its trajectory or created two distinct points to align a trajectory. Regardless of the ability to reconstruct a trajectory, each identified defect in a shooting scene must be photographically documented.

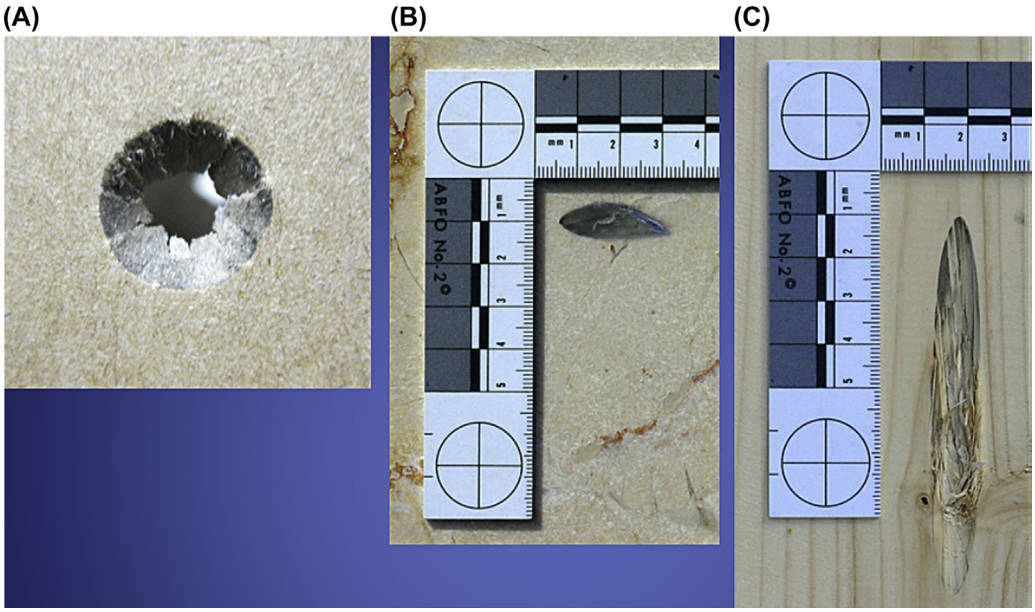


FIGURE 9.5.6
(A) Defect created by a bullet striking the target at a 90° angle. (B) Ricochet mark on granite caused by a bullet striking the surface at a 20° angle. (C) Ricochet mark on wood caused by a bullet striking the surface at a 7° angle.



FIGURE 9.5.7
Angled bullet defects in laminated glass. While not always possible, the fracture lines can be used to sequence the shots order.

The trajectory created by a bullet into or through a target produces two angles requiring analysis and documentation. The first is the horizontal angle, also known as the azimuth. The horizontal angle measures the degree of the trajectory to the right or left of the horizontal plane. The second is the vertical or elevation angle. The vertical angle measures the degree of the trajectory up or down along the vertical plane. The analyst can reduce defect contamination or destruction by measuring each bullet defect to establish its physical position prior to inserting trajectory rods into the tracks created by the bullet penetrating or perforating the object(s).

PHOTOGRAPHING THE TRAJECTORIES

To photographically document the vertical angle, the analyst positions the camera on a tripod perpendicular to the previously inserted trajectory rod. This precise method allows for measuring and calculating of the trajectory angle using the resulting photograph of the rod. When photographing the trajectory rod, the analyst should include a plumb line in the field of view and adjacent to the rod. To measure the angle of the photographed trajectory, the analyst can employ the use of a protractor on the image. Calculating vertical and horizontal trajectory angles is possible when examining these images and exercising the use of trigonometry (Figs. 9.5.8 and 9.5.9).

Placing an inclinometer onto the trajectory rod is another method for determining the vertical angle. To measure the vertical angle with the inclinometer, the analyst positions the device carefully on the rod and reads the indicated angle. When photographing the inclinometer, the analyst positions the camera perpendicular to the rod and inclinometer. Calibrating the inclinometer before its use is an important first step in employing the device to determine angles. A calibrated inclinometer must show a zero reading on a level surface prior its application to measuring the elevation angle of a trajectory rod (Fig. 9.5.10).

The analyst can photograph the azimuth by positioning the camera above the trajectory rod with the lens facing downward. Before photographing the horizontal angle, the analyst must place a corresponding reference into the field of view. A protractor works well for this purpose and can be used to indicate the azimuth as well. To identify the azimuth the analyst positions a zero-edge protractor level and centered at the bullet entry point, and then places a plumb line contiguous to and touching the rod, so that the plumb line just touches the edge of the protractor. The observed point of coincidence between the plumb line and the protractor references the azimuth of the trajectory (Fig. 9.5.11).

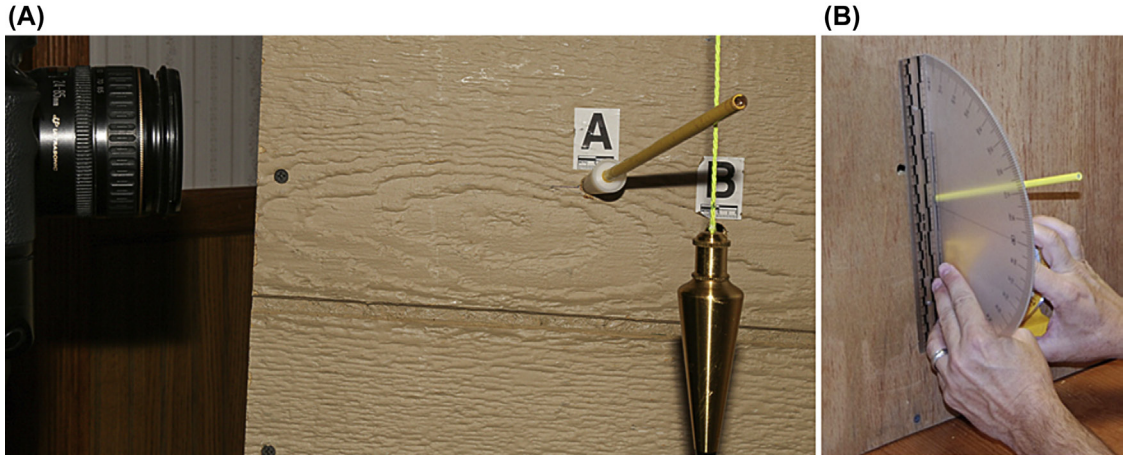


FIGURE 9.5.8
(A) Proper positioning of the camera to a trajectory rod. Note the presence of the plumb line. (B) Measuring the vertical angle using a zero-edge protractor.

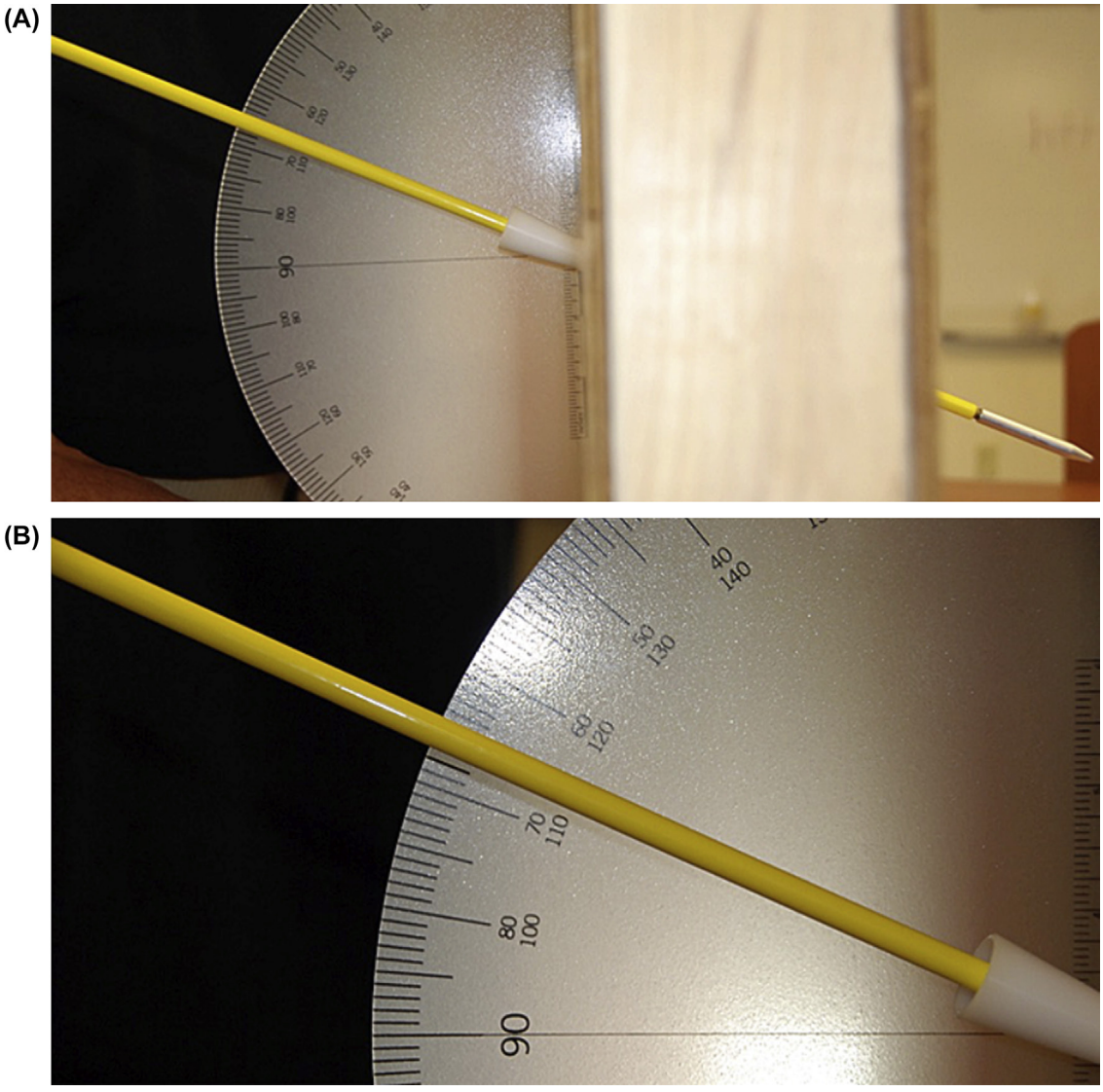


FIGURE 9.5.9
(A) Vertical angle indication using a protractor. The camera is positioned parallel to the trajectory rod. (B) Close-up of a vertical angle indicated with a protractor.



FIGURE 9.5.10
Vertical angle indicated by using an inclinometer.

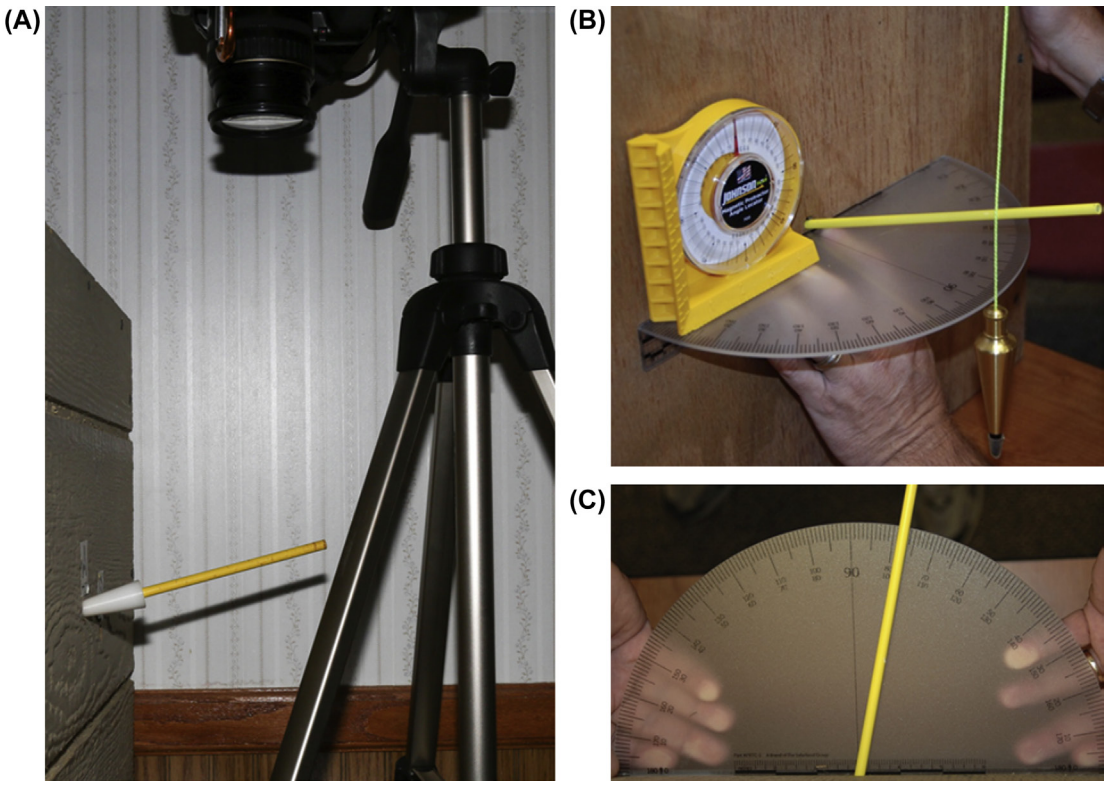


FIGURE 9.5.11
(A) Proper camera orientation when photographing a horizontal angle. (B) Measuring the horizontal angle. Note the use of an inclinometer for leveling the protractor and the use of a plumb to indicate the precise angle. (C) Overhead view of a trajectory rod and properly positioned protractor.

Beginning the process of trajectory analysis involves evaluation, measuring, and photography before the physical insertion of trajectory rods into the identified bullet defects. After roadmapping the bullet holes, the trajectory analysis continues by inserting a rod and centering it in the bullet hole. If the diameter of the bullet hole is larger than the rod, centering cones should be used to both stabilize and center the rod. The process of creating a clearly visible trajectory requires photographing the reconstructed trajectory from multiple angles, including parallel and perpendicular to the target surface and perpendicular to the rod in the elevation and azimuth views (Fig. 9.5.12).

Although trajectory rods are the most recognized devices used for trajectory analysis, lasers are excellent tools for visualizing bullet trajectories over greater distances. The light emitted by a laser does not sag, warp, or bend and provides the most accurate trajectory results. Laser light is unaffected by the forces of gravity and friction. Therefore, laser beams follow a straight line over vast expanses. A bullet's parabolic or curved trajectory results from the influence of forces that do not affect the laser. As the majority of shooting incidents occur over relatively short distances, the parabola is negligible. Photographing the enhanced trajectory results in a straight line demonstrative, which is consistent with the expected trajectory over those short distances (Fig. 9.5.13A).

Lasers suitable for use in reconstructing trajectories come in many types, styles, and price ranges. Specifically manufactured in-line lasers attaching directly to the end of the trajectory rod, or those constructed with the laser being part of the rod itself are often more expensive options for an analyst. Adapting commercially available laser pens, levels, or other laser devices for use with the trajectory rod is another method useful for reconstructing bullet paths. An analyst choosing a slightly offset option requires consideration of any variance between the center of the rod and the laser light beam to determine the true trajectory, however, the discrepancy does not have an effect on the demonstrative value of the photographically augmented trajectory. Inexpensive laser device options available in several retail outlets are an acceptable alternative for photographically creating a laser line demonstrative at a scene where the goal is establishing a visible trajectory.

While the dot projected from a laser is often easily seen, visualizing the laser beam through the air is normally not achievable in most ambient light instances. Creating a visible beam is best achieved using darkened conditions or through the addition of reflective medium. The most common methods employed for the purpose of adding reflective surfaces to the laser are misting where commercially available spray fogs create minute particles suspended in the air, or using the technique of "walking the laser" which requires physically moving solid flat surfaces along the beam's path while a camera captures the action.

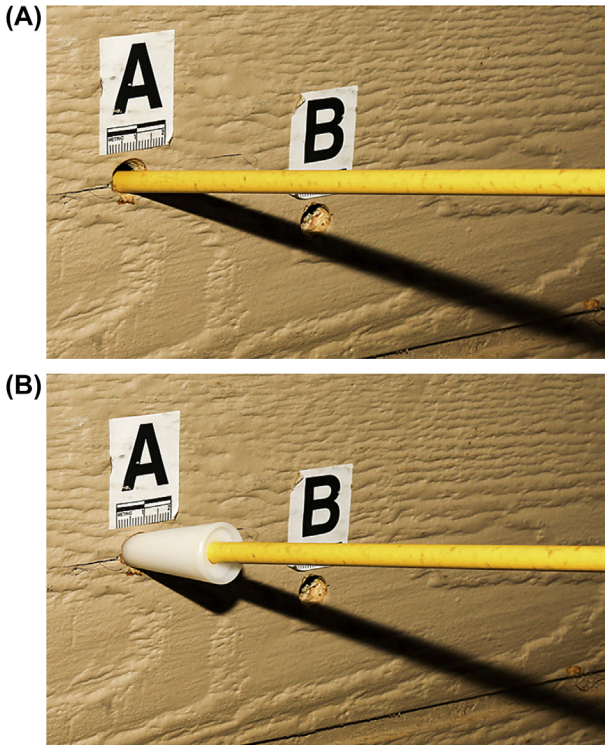


FIGURE 9.5.12
(A) Horizontal angle indicated through the use of a trajectory rod. (B) Using a centering cone.

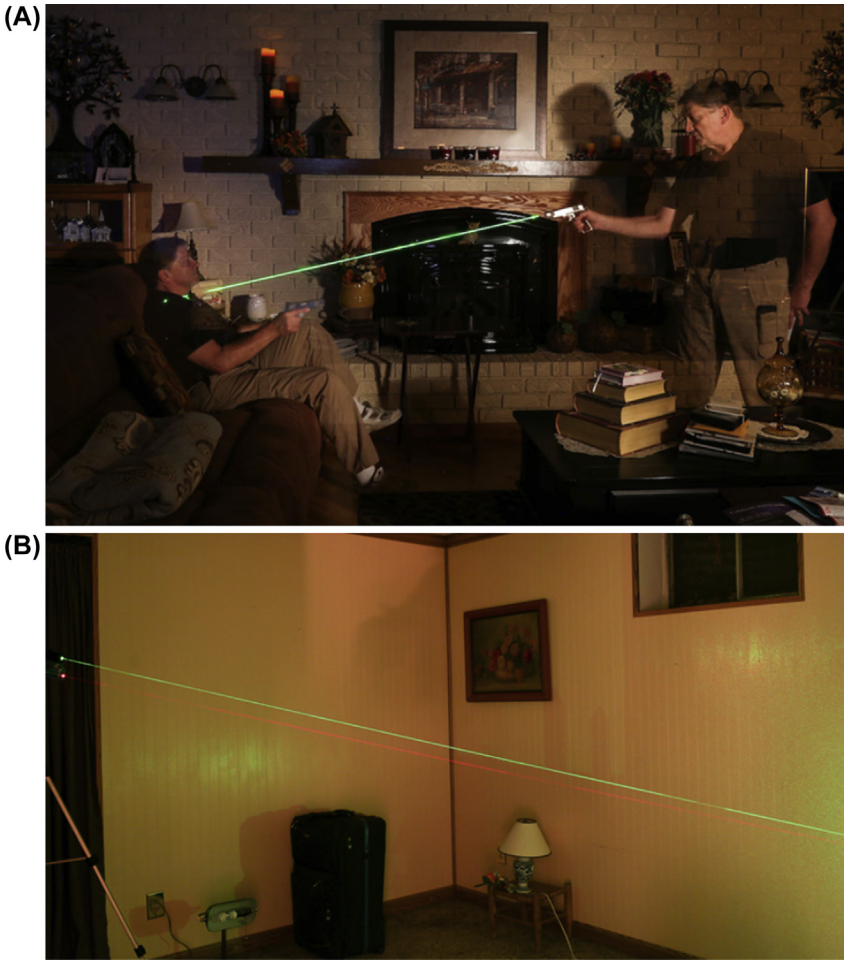


FIGURE 9.5.13
(A) Walking the laser and painting with light example. ISO 400 f/22 for 16 s. (B) Fog enhanced laser in a dimly lit room. ISO 400 f/4 for 9.2 s.

Spray fogs are beneficial for producing visible spans of the beam in diverse lighting conditions. Laser beams enhanced by these aerosolized fogs or fine particulates are observable by individuals at a scene and are easily recordable by video or still photography. Ambient or low light images may be recorded using fogging sprays, but repeated applications during the process of photographing may be necessary. Disadvantages of particulate creating sprays include dispersion by airflows, slight clouding of the scene, and depositing spray residues on all objects in the area of deployment. In addition to the use of a specifically manufactured fogging spray, an analyst can use water applied from an atomizer, or other fine mist aerosols including hairspray, cooking oil, and antiperspirants. The disadvantages associated with these substances are similar to those found in the purposely designed fog but add with their use many other predictably undesired results (see Fig. 9.5.13B).

Absent the availability of a high-powered laser device producing a visible beam that can be photographed using limited enhancement, "walking the laser" is the best means of creating a precise laser trajectory in a scene employing still photography. Low light conditions and extended exposure photography can produce exceptional representations of trajectories using inexpensive laser devices.

Walking a reflective card along a laser beam is a simple method for creating a visible laser trajectory photographically without an atomizer formed particulate cloud. To accomplish quality "walking the laser" results, the analyst must use manual or lengthy time programmed camera settings allowing for narrower apertures and extended shutter speeds.

Capturing the entire laser beam photographically, the analyst often begins with darkened conditions. Capturing a laser trajectory in limited light conditions will show the enhanced laser beam, but the areas surrounding the trajectory line may not always be discernable in the image. Using low or dimly lighted conditions while moving a solid surface along the beam has the advantage of improving recording the surroundings as well as the laser beam.

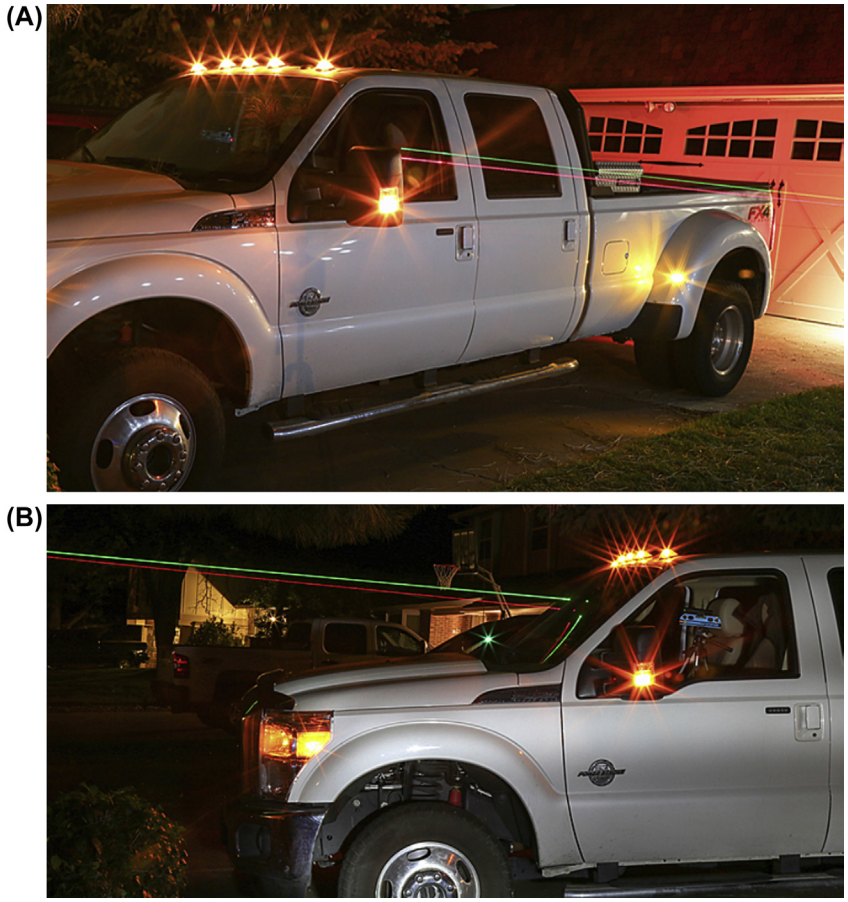


FIGURE 9.5.14
(A) Walking the laser and painting with light example. Laser projected through the windshield. ISO 400 f/22 for 14 s. (B) Walking the laser and painting with light example. ISO 400 f/13 for 19 s. Green laser is best for this process, however, red laser is also visible. ISO 400 f/4 at 1.8 s using an ND 3.0 filter.

To reduce or eliminate a ghosting effect, the person moving the solid surface used to reflect the laser must remain in motion while the camera shutter is open. When walking the laser is performed correctly, the camera captures the beam and nonmoving objects in the image, but the person transporting the reflective surface does not appear in the final image (Fig. 9.5.14).

The use of a standard electronic flash set to full or normal illumination can capture the various scene components, but can obscure the laser light indicating a trajectory. When observing the scene elements in the final photograph is desired, the analyst can employ "painting with light" techniques to provide sufficient illumination of the scene or subject of the photograph when documenting laser beams in diminished lighting conditions. These so-called painting with light techniques benefits from the use of an electronic flash programmed to lower power settings, through the use of flashlights, or via a combination of both. Ancillary lighting methods are valuable for enhancing the scene areas surrounding the reconstructed trajectories.

Visible laser trajectories are also attainable in normal and bright daylight conditions. The analyst can accomplish this task through the use of a bright green laser, a reflective card, and a neutral density filter for the camera. While the exposures are usually less than those required for darkened conditions, the procedure for visualizing the laser beam is the same (Fig. 9.5.15).

CONCLUSION

Reconstructing and sequencing the events of a shooting incident are strongly linked to the proper documentation and processing of the scene. Evidence recorded and collected at the scene can support conclusions regarding the types and numbers of firearms involved, the kinds and classifications of ammunition used, and the directions and angles of bullet travel. Moreover, information gathered from examining the evidence collected photographically can answer specific reconstruction questions. An example includes calculating the maximum horizontal distance of a shooter from the target surface when the analyst knows the vertical distance (maximum height of the firearm).

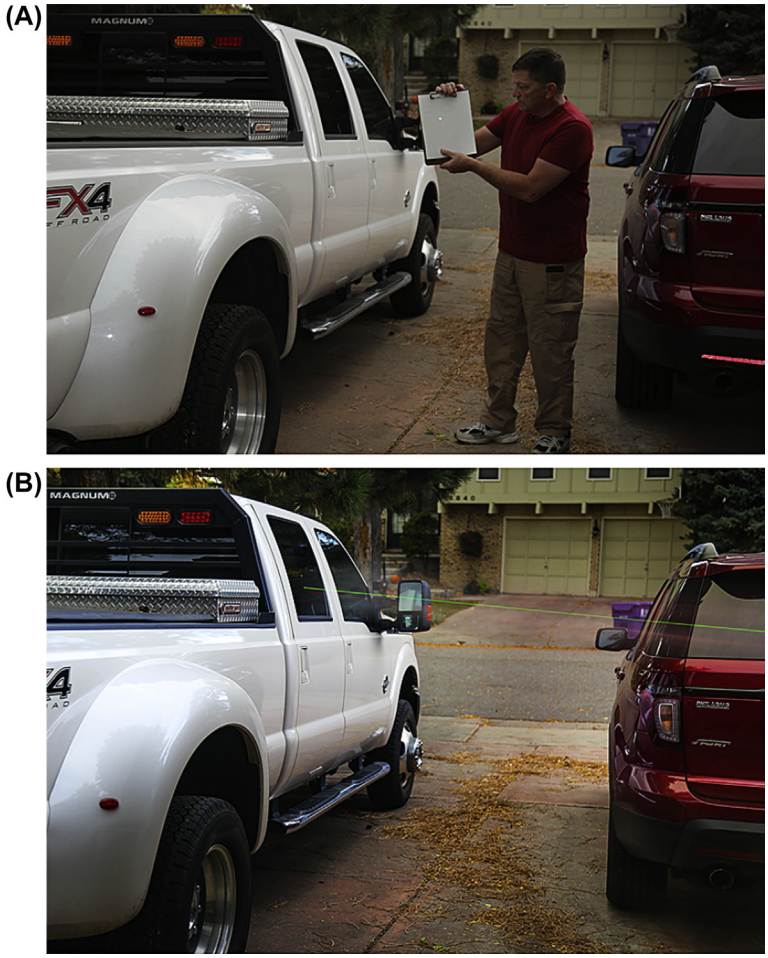


FIGURE 9.5.15
(A) White card stock held at an angle toward the camera reflecting the laser light. (B) Walking the laser in daylight condition. ISO 400 f/13 for 19 s.

Accurate and completely photographed scenes permit remote analysis of a shooting incident when an analyst is unavailable to respond to the active scene. Photographs are also beneficial when further evaluation of the scene becomes necessary as a result of identifying additional evidence. The photographs captured at the scene and used together with the assessment completed by a trained analyst represent the fundamental understanding of what did or could have occurred and what could not occur during a shooting incident and firearm discharge.

Proper photography of trajectory rods allows for later reconstruction of the bullet paths. Appropriately employed laser photography techniques provide the viewer of the image a demonstrative of the reconstructed trajectory. Methodically documented and accurately photographed bullet trajectories offer an understanding of the shooter positions, the number of shots fired, and an overview of the shooting incident.

USEFUL SHOOTING INCIDENT DEFINITIONS

Azimuth	Refers to the angle of trajectory on the horizontal plane.
Elevation	Refers to the angle of trajectory on the vertical plane.
Trajectory	The path followed by a projectile from its origin to its terminus. Often characterized as a parabola or curved path, the trajectories or bullet path related to fired projectiles investigated by law enforcement agencies are often considered straight lines due to the generally close distances between shooters and targets.

Further Reading

Wolson, 1997. Toby L. Bloodstain Pattern Analysis Workshop Manual. Metropolitan Police Institute, Miami.

SUBCHAPTER 9.6

Surveillance Photography

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Key Terms
Digital Noise
Motion Controlled by Fast Shutter Speeds
Photoshop
Push Processing
Spot-Metering
Telephoto Focal Lengths

Learning Objectives

1. Explain how to determine the focal length of the telephoto lens to be used for a particular surveillance job.
2. Explain how to select the appropriate shutter speed to eliminate the potential blur from handholding the camera during surveillance situations. If this is not acceptable, then using a tripod is recommended.
3. Explain how the appropriate shutter speed is selected to freeze the movement of the suspect under surveillance.
4. Explain how it is predetermined that the surveillance suspect will be in focus, even if he or she will be moving within different distances from the camera.
5. Explain how to select the appropriate ISO for the dim lighting conditions that may be present at nighttime surveillance scenes.

LENS SELECTION

A Rule of Thumb greatly simplifies the selection of the focal length of the telephoto lens to be used in long-distance surveillance situations.

RULE OF THUMB 9.4

Use 2 mm of lens for every foot of distance between the camera and the subject.

For instance, if you know that it will be safe to set up in a position that puts you at a distance of 600′ from where the suspect will be, then a 600 × 2 = 1200 mm lens will be required to be sure of recognizing the suspect's face or to be sure that the suspect's license plate number can be read at that distance. This makes it necessary that the intelligence information available for the particular job be fairly accurate. It also means that important surveillance photographs have to be planned well, and they should not be ad hoc enterprises. In other words, this type of photography should be well planned and not thrown together just before the actual photo shoot.

Fig. 9.6.1 shows three images of a relatively close George Washington, who is just 50′ from the camera. George's cropped and enlarged head clearly shows image degradation with the 24 mm lens (0.5 mm of focal length per foot of distance) and the 50 mm lens (1 mm of focal length per foot of distance). With the 100 mm lens (2 mm of focal length per foot of distance), the enlarged head is sharp and clear, which is the basis of Rule of Thumb 9.4. Remember, these three images were taken in the middle of the day in good weather. With other variables in play, such as further distances and during the night with poor lighting, you will want the confidence that the effort to capture the images pays off with recognizable images.

SHUTTER SPEED SELECTION TO HANDHOLD TELEPHOTO LENSES

The previous shutter speed recommendation for handholding any focal length lens applies to surveillance photographs also. The focal length of the lens made into a fraction is the safe shutter speed to use to be sure that there will be no blur from your heartbeat while handholding the lens. For example, a 200 mm lens made into a fraction is 1/200. The closest shutter speed to 1/200, on some cameras, is 1/250 of a second if it is necessary to handhold the camera.



FIGURE 9.6.1
The proper lens for the distance: 2 mm per foot of distance.

In practice, however, that is such a fast shutter speed that it is usable only in bright lighting conditions. Even in bright lighting conditions, however, it is advisable to put the camera on a tripod to enable slower shutter speeds. As will be explained shortly, slower shutter speeds allow slower ISOs to be used, which is important, because as the ISO goes up, the quality of the photograph goes down (shown as increased **Digital Noise**), whereas the contrast goes up (shown as a loss of middle gray tones). Neither is desirable.

As mentioned in Chapter "Basic Exposure (Nonflash) Concepts," where lenses were discussed, image stabilization (IS) and vibration reduction (VR) lenses would be a distinct advantage in surveillance situations in which dim lighting or telephoto lenses are used.

In dim lighting conditions, the alternative of putting the camera on a tripod to avoid blur from handholding the camera is almost always required. This would enable using much slower shutter speeds, which impacts the ISO selection. Under the dim lighting conditions of nighttime surveillance photography, using the slowest ISO rating possible is also a consideration, since this affects the quality of the print due to the increase of noise and loss of contrast as the ISO increases.

For example, presume an f/4, 1/500, ISO 3200 film, and handholding a 500 mm lens under dim lighting conditions results in a good exposure. If the camera were mounted on a tripod, the shutter speed could be slowed to 1/125 second,

which would freeze the suspect expected to walk out the back door of a residence. Changing from 1/500 to 1/125 allows two stops more light to reach the film. That savings can alternatively be applied to the ISO to reduce the possible digital noise of the photograph. That means you would be able to select an ISO that is two stops less sensitive to light: 3200 to 1600 is one stop; and 1600 to 800 is another stop. Therefore, just by switching to a tripod, you can take the photograph at f/4, 1/125, ISO 800 in the same lighting conditions, netting a slower ISO for more sharpness and clarity.

SHUTTER SPEED SELECTION TO FREEZE MOVEMENT OF A SUSPECT

Previous shutter speed recommendations to freeze movement apply to surveillance photography as well:

- 1/125 will freeze a person walking or talking and turning his or her head to speak to different people.
- 1/250 will freeze a person jogging, jumping, or riding a bicycle at normal speeds.
- 1/500 will freeze a person in a car traveling at 30 mph.
- 1/1000 will freeze a person in a car traveling at 60 mph.

The anticipated movement of the suspect has to be built into the exposure calculation of surveillance photography, which is so important that it is a Rule of Thumb.

RULE OF THUMB 9.5

The shutter speed for all surveillance photography must be selected to freeze the anticipated movement of the subject to be photographed. Although shutter speed is certainly an exposure variable, when you are doing surveillance photography, freezing subject motion is the shutter speed's primary function.

CALCULATING FOCUS OR DEPTH OF FIELD

If you recall, one of the factors affecting depth of field is the camera-to-subject distance. Therefore, even when using wide apertures, a decent depth of field will be available when photographing at normal surveillance distances if you just focus at infinity. Usually, it will be enough to ensure that someone within a 20′ range is in focus. Think of that as the width of a sidewalk outside many businesses. Even with a depth of field scale on the camera lens, this is difficult to determine more precisely.

When more precise calculations of the area of the scene that will come back in focus are required, the recommendation is to take some practice shots before taking the actual surveillance photos. Try to duplicate all the variables that will exist in the required situation:

- Distance from subject
- Shutter speed to stop anticipated movement, tripping the shutter with a shutter-release cable
- Focal length of the telephoto lens
- ISO setting
- F/stop selection
- Lighting conditions
- Focus on infinity
- Camera mounted on a tripod

Take several digital shots and examine the results.

ISO SELECTION

How can you determine the ISO required for the surveillance conditions that are anticipated? Rather than just setting your digital camera to its highest ISO setting, you should use the slowest ISO possible for the lighting conditions because the slower the ISO, the better the quality (low noise) and contrast of the final photograph. This point is so important that it becomes a new Rule of Thumb.

RULE OF THUMB 9.6

Use the slowest ISO possible for the lighting conditions at the scene when taking surveillance photos.

To determine the slowest ISO that can be used, just set all the other exposure variables, mentioned previously, and begin taking meter readings of a surrogate scene lit the same way the real scene is expected to be lit. Even better is to take a meter reading of the actual scene several days before the real shoot. Take a meter reading with the camera set at ISO 400. Set the widest aperture of the lens, and the shutter speed to freeze the subject's anticipated motion. If the meter indicates that this will result in an underexposure, try the next faster ISO, 800. Continue until the meter indicating a proper exposure has been obtained. Using a faster ISO than necessary diminishes the quality of the photographs unnecessarily.

Here is one final observation about these meter reading trials. If the camera has **Spot-Metering** capability, use it. Otherwise, the possible lighter or darker ambient light around the subject of interest may cause the subject to be improperly exposed because an averaging, center-weighted, or even matrix meter is evaluating *all* the light being reflected from what is viewed in the center of the viewfinder. Possible dark ambient lighting around the subject of interest may cause the subject to be overexposed. You are not concerned about properly exposing the inside of the store the subject may be walking in front of. And, you are not interested in properly lighting the dark background surrounding your subject. All you are interested in is properly exposing your subject. Average or center-weighted meters react to all the light coming from the central area of the viewfinder. Even matrix metering modes are not ideal for this situation. If you do not have a spot meter, several days before the real shoot, position a helper in the spot the suspect is expected to be in, and come in close enough to *fill the frame* with just the light reflected off the helper's body, excluding all the other light around him or her, and use that exposure reading for the real shoot.

DAYTIME SURVEILLANCE PHOTOGRAPHY

When you are taking daytime surveillance photographs, it is obviously necessary to stay out of sight. When the lighting is adequate to see, and be seen, for long distances, it becomes important to hide the camera and yourself. The question is then how you can hide a camera yet still get the images required. At first, you might consider hiding behind a wall or large tree trunk or even behind a bush. If you have the camera lens peeking around a wall, tree trunk, or bush, won't the lens be obvious enough to be recognized as a camera lens?

You must remember that long telephoto lenses are quite large. Fig. 9.6.2 shows the two lenses used for all the following images. They are not petite lenses. It will be necessary to keep them from being recognized by the suspect as camera lenses.



FIGURE 9.6.2
(A) Canon 400 mm lens with 2× teleconverter. (B) Sigma 800 mm lens.
Courtesy of Tom Beecher, Photografix, Richmond, VA; Courtesy of Air Force Office of Special Investigations, AFOSI.

This task is made easier if you recall the three factors that affect depth of field:

- Aperture selection
- Lens selection
- Camera-to-subject distance

Rephrase this, and you can determine the three factors that minimize depth of field:

- Use the widest aperture of the lens.
- Use a telephoto lens.
- A close camera-to-subject distance minimizes the depth of field. In this case, being close to the obstruction you are using for concealment will help ensure it blurs when the image is captured.

Through a careful use of these three factors that minimize depth of field, you will now learn how to hide your camera and giant telephoto lens behind solid obstructions while still being able to capture an image of your suspect.

Fig. 9.6.3 shows a combination of images illustrating a typical "surveillance" photograph of a subject sitting on a bench at the opposite end of the George Washington University Quad, which is about 300′ between camera and subject. The top left image shows the wall the camera will be hidden behind, as indicated by the circle. The bench the "suspect" will be sitting on is located in the foreground of the top left image. The other top images show how much of the lens is behind the wall and how much is required to capture a recognizable image of the subject. Even if the subject were looking directly at the camera's position, the small slice of camera projecting from behind the wall would not be recognizable. The bottom left image shows the camera's position behind the wall. The person with the blue shirt is standing where the "suspect" will eventually be seated. This distance between camera and suspect position appears vastly compressed because another telephoto lens was used to capture this image. The bottom middle image is the actual "surveillance" shot. The bottom right image is an enlargement of the "suspect's" face.



FIGURE 9.6.3
Photos across George Washington University's quad.

You may wonder why the subject's face is not as sharp as George Washington's face in Fig. 9.6.1. After all, using an 800 mm lens for a 300′ distance is overkill, is it not? If there were no obstruction between lens and subject, this would be true. However, by putting so much of the lens behind the wall, some of the possible resolution of the lens is compromised. Although this image is not as sharp as George Washington's face, the sun-glassed smoker would easily be recognized.

Fig. 9.6.4 shows how a series of nighttime photos were set up. During the daytime, student Tonia Busse stood 400′ away from a camera with a 50 mm lens, with the camera mounted on a tripod. She is almost impossible to see in the left image. Enlarging the circled area is not much of an improvement. Obviously, the 50 mm lens does not capture sufficient detail to recognize her. The right image depicts Tonia standing in the same position at night but photographed with an 800 mm lens. She and the license plate are easy to recognize. If you have good eyes, you may be able to see that the license frame indicates "Jerry's," the dealership that sold the car. This position, with Tonia 400′ from the camera will be seen again soon.

Using camera equipment properly can make solid objects "disappear." First, a simple trick.

Fig. 9.6.5 shows a "wild bunny" in a yard. The scene was intentionally composed so part of a chain-link fence crosses the bunny's body. In this case, a 100–300 mm zoom lens is being used with a 2× teleconverter on a digital camera with a 1.6 focal length multiplier. The effective short focal length of the lens would, therefore, be 100 × 2 × 1.6, or the equivalent of 320 mm. The effective long focal length of the lens would be 300 × 2 × 1.6, or 960 mm. The top left image is a view from the short end of the telephoto lens, 320 mm. The top right image is the beginning of the lens being zoomed out. The bottom left image has the lens zoomed out even more, and the bottom right image has the zoom lens zoomed about 3/4 of the full travel distance of the lens. Notice that the chain-link fence is beginning to appear soft because it is becoming more and more out of focus. The middle image shows the result when the lens is zoomed out all the way to the 960 mm focal length. The chain-link fence has "disappeared" because it is so out of focus.

Many people taking photographs at the zoo use this technique. If you cannot find a position to photograph animals without the cage in the way, make the cage disappear by following these tips:

- Use the longest focal length lens you have.
- Use the widest aperture of your lens.
- Get close to the cage and focus on the animal. Being close to the cage will help ensure that the cage is outside the animal's depth of field range.

Let us make the intermediate obstruction a bit thicker.

Fig. 9.6.6 shows the setup in which a neighbor's car across the street is being composed through the branches of a tree. In this case, the front license plate has intentionally been obstructed by a tree branch. The same 960 mm lens was used



FIGURE 9.6.4
400′ away with 50 mm lens (day) and 800 mm lens (night).
GWU MFS Student Tonia Busse.



FIGURE 9.6.5
A wild bunny and the disappearing fence.



FIGURE 9.6.6
A thick tree branch becoming transparent.
Courtesy of GWU MSF student E. Murray.

as with the "wild bunny." The top left image is at the 320 mm end of the zoom range. The top right and bottom left show progressing zooms toward 960 mm. The bottom right is the 960 mm setting; the branch is now so out of focus that it appears to be transparent. The middle image is a crop and enlargement of the tag.

Fig. 9.6.7 shows the application of this concept to a situation frequently used by surveillance photographers. Rather than hide behind a leafless tree, you can position the camera behind a bush large enough to conceal the photographer and camera on a tripod. Of course, when set up as seen in Fig. 9.6.8, it probably would have been possible to actually get a direct shot of the license plate without leaves in the way. But, that is not a challenge! In this image, the composition was arranged so that leaves did obstruct the view of the license plate. This was taken with the zoom lens at its shortest focal length. Once the lens was zoomed out to it longest focal length, the leaves went transparent!



FIGURE 9.6.7
Tag obscured by leaves.
Courtesy of GWU MSF student S. Wise.



FIGURE 9.6.8
Leaves made transparent.
Courtesy of GWU MSF student S. Wise.

A variation of this theme is also frequently used by officers doing surveillance photography. Many times the officers can set up the camera equipment in a building near where a suspect is likely to be, or where their vehicle will be parked. By using venetian blinds to hide behind, only slight cracks between blinds will completely obscure the officer and their camera equipment from the suspect. In fact, from the suspect's point of view, the venetian blinds will appear to be complete closed. See Fig. 9.6.9.

To make things interesting, one of the venetian blinds has intentionally been positioned to be over the license plate of interest. It would be too simple to position the camera so it "saw" between the cracks. The same procedure is used: at the short end of the zoom lens' range, the venetian blind still obstructs the view of the tag. At the far end of the lens' zoom range, the venetian blind becomes "transparent," and the tag can be read easily. The bottom right image shows what a suspect would see if looking directly at the camera's position. The camera is positioned behind the left window with blinds "closed."

If you cannot find a bush or venetian blinds to hide behind, any wall or thick tree trunk will also suffice. Just ensure that 10–15% of the lens still has an unobstructed "view" of the subject of interest, while the rest of the lens is hidden behind the obstruction. With just a sliver of the lens peeking around the obstruction, the suspect will not recognize it as a camera lens.

This is where the techniques mentioned above truly show their usefulness. No more making a leaf or chain-link fence disappear. How about a cement wall? See Fig. 9.6.10A. In the left image, one can see on the right, a short wall which will eventually be arranged between the camera lens and the couple sitting on the bench in front of the townhouse and white van. The top right image shows this couple again, with the camera on a tripod, but with no obstruction at all. The lower right image shows the result of the tripod being lowered so the wall is now obstructing everything above the white van. Both of the right images have the same point of view; the lower right image just has the camera lowered behind the wall. At this point, the zoom lens is at its shortest focal length.

As the focal length of the lens is zoomed out to its longest focal length, 960 mm, the top of the wall begins to blur more and more. So much so that the couple on the bench are now visible. The top image of Fig. 9.6.10B is a cropped view of just the couple on the bench. Absolutely no trouble recognizing either one of them, correct? And, the lower image enables us to also know what kind of shoes the male is wearing! As much as this author tried, one could not tell the time based on the male's watch. Had the couple looked toward the wall, the slight bit of lens above the wall could not have been recognized as a camera lens.



FIGURE 9.6.9
Seeing through Venetian blinds.



FIGURE 9.6.10 (A)
A couple on a bench to be photographed from behind the wall on the right.



FIGURE 9.6.10 (B)
A couple on a bench photographed from behind the wall.

DEALING WITH UNDEREXPOSED IMAGES

With nighttime surveillance photography, hiding behind obstructions is not as important. Because of limited visibility in the dark, many times it would be almost impossible to see the camera and photographer, even if both were totally unobstructed. Of course, being unobstructed should still be avoided, in case a changing lighting situation, like a car coming around a corner, temporarily throwing light directly on the photographer. For nighttime surveillance photography, the main problem to be overcome is underexposure.

When the light becomes dimmer, the fast-speed ISOs come out to play. Or, at least that is what the camera manufacturers suggest when they advertise their fast ISO cameras. Sure, 800 ISO and even faster 1600 ISO and 3200 ISO are also available. Some digital cameras also have faster ISO settings. Several camera manufacturers are even sporting ISOs at 102,400 or faster! Are these sufficient to properly expose all nighttime scenes? No.

Unfortunately, even these fast ISO digital equivalents cannot provide proper exposures under extremely dim lighting conditions. That is when infrared lighting or light-intensifying night scopes become invaluable. These lighting solutions are clearly beyond the regular crime scene photography scope of this book, so this text is confined to more "normal" solutions.

"PUSH-PROCESSING" FILM

Why include any information on film when we are clearly now almost exclusively using digital cameras at crime scenes? This brief section will be used just for a comparison between film and digital "solutions" to scenes likely to result in underexposes.

When you knew that the film would likely be underexposed, you could ask that the film be "push processed" in the darkroom. **Push Processing** could sometimes bring out underexposed detail on the film. This meant that the film would be developed differently than normal film. Usually, it meant the film will be allowed to remain in the chemical developing baths longer. For this technique to work, it is essential that you ascertain the exact level of pushing necessary.

For example, presume the widest aperture of your 800 mm lens is f/5.6. Because your target will be a subject sitting at an outdoor café table, talking to co-conspirators, you set the shutter speed to 1/125 s. You have loaded the camera with 3200 ISO film, and several days before the actual shoot, you had a friend sit at the table known to be favored by the suspect. Your meter readings on your friend have all indicated an underexposure. How is the precise level of underexposure determined?

Change the camera's shutter speed setting to 1/60 shutter speed and take a new meter reading. If the new meter reading still indicates an underexposure, change the shutter speed to 1/30 and take another meter reading. Still underexposed? Change the shutter speed to 1/15. Now, pretend the meter indicates a proper exposure. Of course, you cannot actually use the 1/15 shutter speed, but now you know precisely that the exposure with 1/125 is exactly three stops underexposed. You can take photos at 1/125 shutter speed and then tell the darkroom operator the film needs a "three-stop push." Each "push" requires a longer time the film will remain in the developing chemicals.

You need to understand two issues here: "pushing" film results in both an increase in graininess and an increase in the contrast of the images. Mid-tones will be lost. Therefore, "pushing" film has its limits. At some point, the resolution of the desired image will be totally lost. Research indicated that "pushing" film about three stops was usually the practical limit, and this presumes you are dealing with a highly skilled professional laboratory, not your local drugstore.

Fig. 9.6.11 shows this sequence of progressive contrast and increased graininess with more and more "pushing," which is the continuation of the previous shots with Tonia Busse 400′ from the camera with an 800 mm lens being used. During the nighttime, the proper exposure was determined, and then a series of progressively dimmer exposures was set on the camera. The two-stop "push" shows that Tonia's face has become extremely "contrasty," with mid-toned grays completely gone. The 3-stop "push" begins to lose her face to graininess, while her blouse has gone contrasty. A license plate was added, anticipating the ability of the "pushed" film to record fine details of the tag longer than facial details. The 3-stop "push" shows the tag clearly. With four stops of "pushing," both Tonia's face and the tag are no longer recognizable, but the gross blouse shape can still be made out. At five stops of "pushing," not much can be identified.

Beyond three stops of "pushing," it would be wise to implement infrared lighting with infrared-sensitive cameras or to begin using night scopes, which are variations of military light intensifiers.



FIGURE 9.6.11
Push processing limit.
GWU MFS Student Tonia Busse.



FIGURE 9.6.12
Digital processing of underexposed images.
GWU MFS Student Tonia Busse.

DIGITAL PROCESSING OF UNDEREXPOSED IMAGES

As the march toward converting crime scene cameras from film to digital cameras continued, the natural question become, "Can underexposed digital images be successfully salvaged?" If so, is the digital processing of underexposed images more or less successful than it was for underexposed film images? The answers are "Yes" and "More."

Fig. 9.6.12 shows a series of underexposed digital images salvaged in **Photoshop**. It was the intent of this exercise to keep underexposing digital images to the point of failure, just as was demonstrated with film "pushing." The night of this exercise, the images shown on the digital camera's LED screen were totally black, so it was felt that goal had been achieved. However, when the images were eventually put into Photoshop, detail was retrieved from all the underexposures. This exercise failed to find the "failure" limit of Photoshop processing.

Between the –6 and the –9 exposures, you might even notice a slight improvement in image quality. With confidence that the –6 exposure would fail to have any detail recovered, a new experiment was embarked on. This

experiment could be done with a digital camera, but not with a film camera. With the digital camera, after the –6 exposure with the camera set to ISO 3200, further underexposures were made by changing the ISO setting to slower ISO equivalents, rather than faster shutter speeds; –7 was taken with the ISO set to 1600, –8 was taken with the ISO set to 800, and –9 was taken with the ISO taken at 400. The experiment was to see whether the continued loss of contrast and the increase in digital "noise," caused by increased underexposure, would be offset by the reduction in digital "noise" with the use of slower ISO settings. This seems to be the case, but more experimentation needs to be done. Suffice it to say that the recovery of underexposed detail is much easier in a digital environment than in a film environment.

Since faster and faster ISOs are available on our digital cameras, it becomes necessary for you to test the limits of these faster ISOs under daytime and nighttime conditions. That is the only way to confidently use these ISO at real crime scenes.

In a classroom, I put both a Nikon D3200 camera (24-mp APS-C–sized sensor) and a Nikon D600 camera (24-mp full-sized digital sensor) on tripods and composed on the same scene with a Biohazard sign on a white board, Fig. 9.6.13. One word, "NOT," is the intended target, and that word was intentionally just left as part of the background, rather then made to fill the frame. This was to duplicate the frequent request to magnify/enlarge an aspect of an image which has already been captured.

With each camera, the digital White Balance was set to "fluorescent" and nonflash images were captured while changing the ISOs to maintain a proper exposure by adjusting the shutter speeds as necessary. Close-up crops of the word "NOT" were made, and grayscale was used to eliminate the distraction of color. The goal was to compare image degradation as each camera used faster and faster ISOs. One additional hypothesis was that the D600, with its full-sized sensor, would show less image degradation than the D3200 images.

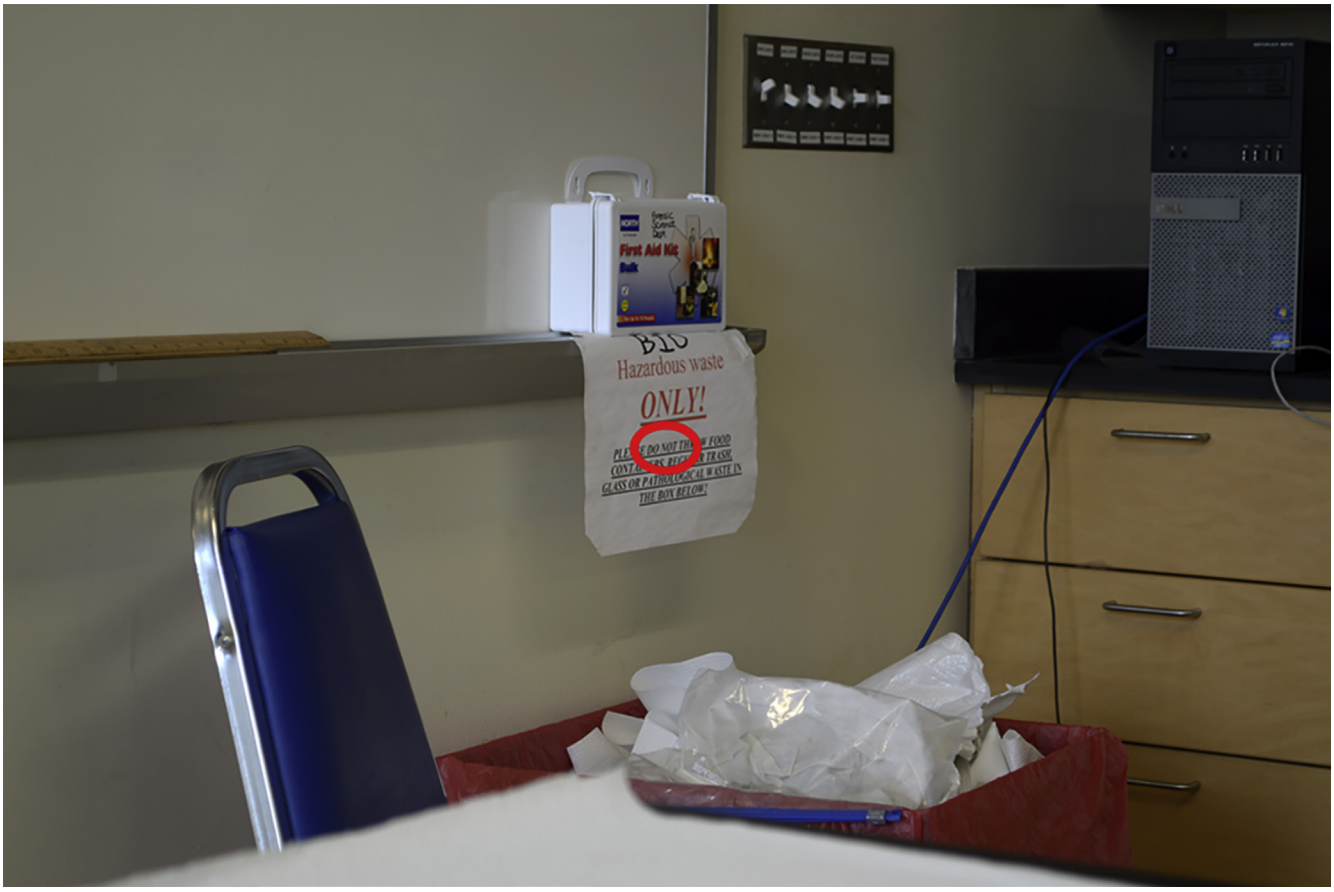


FIGURE 9.6.13
Photo of a room with a sign on the back wall. The word "NOT" is circled.

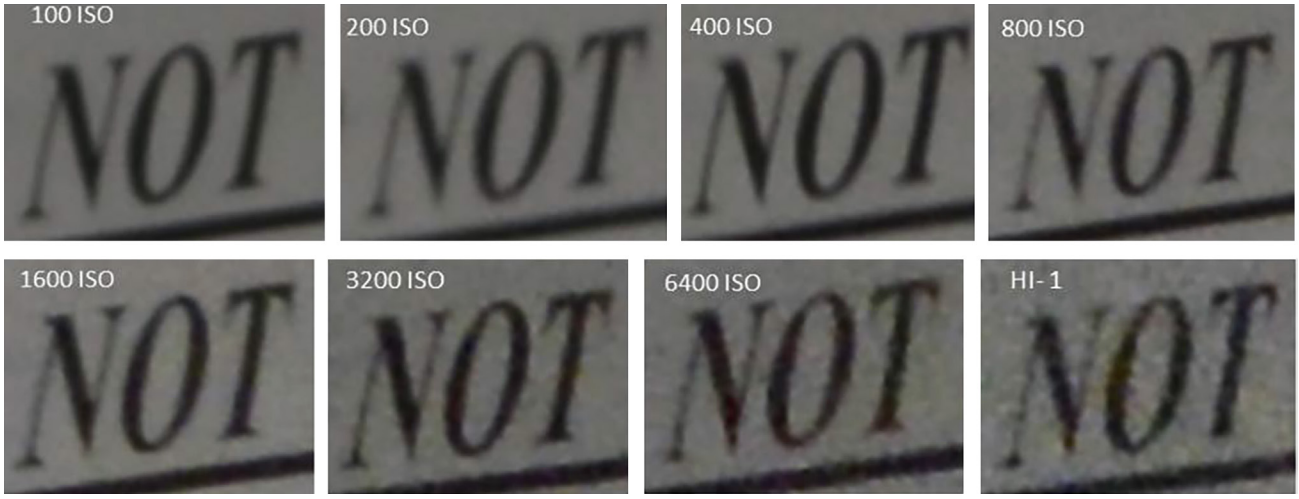


FIGURE 9.6.14
The sign cropped and enlarged with a Nikon D3200 camera, using different ISOs.

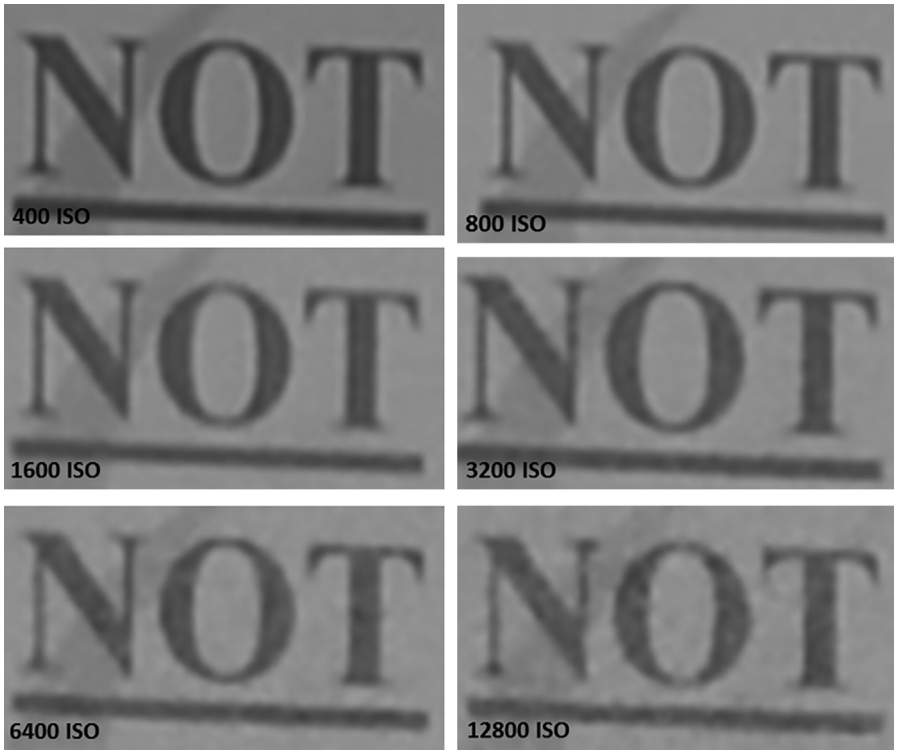


FIGURE 9.6.15
The sign cropped and enlarged with a Nikon D600 camera, using different ISOs.

Figs. 9.6.14 and 9.6.15 are the D3200 and D600 images, respectively. (You should set up a similar test with your digital camera.) Determine where you would be happy to use a particular ISO, but be hesitant to use the next one. Consider two different scenarios: one where they are "normal" images, and one where you are desperate to get any detail you can. Regarding the latter scenario, this author would have no qualms choosing ISO 12,800 with either camera when just getting some usable details is the goal. For my normal photography of crime scenes, however, I would easily use the ISO of 800 with the D3200 camera (Fig. 9.6.14), and consider using the ISO of 1600 in a pinch. With the D3200 camera, the 3200 ISOs and faster are just too noisy. With the D600 (Fig. 9.6.15), as expected, I would go with the 1600 ISO without a problem, and consider the ISO of 3200 in a pinch. The 6400 and 12,800 ISOs are just too obviously noisy.

A similar setup should be done with a nighttime scene to determine your tolerance limits under those circumstances also.

SUMMARY

This chapter covered the normal surveillance photography techniques required to capture recognizable images of a suspect from a distance in both daytime and nighttime situations. The main two differences are that much longer focal length (telephoto) lenses are used to recognize a suspect at a greater distance, and faster ISO films are used to properly expose the suspect under dim lighting conditions. This chapter explained how all the photographic variables are selected for surveillance photography from a distance.

DISCUSSION QUESTIONS

1. Discuss the surveillance photography issues related to lens choice and shutter speed choice.
2. How is the ISO film speed optimally determined in nighttime surveillance photography situations?
3. Explain the camera variables that allow a photographer to blur intervening obstructions to the point they begin to "disappear."
4. Compare film and digital sensors regarding the ability to recover details from underexposed images.

Further Reading

Eastman Kodak Company, 1972. Photographic Surveillance Techniques for Law Enforcement. Eastman Kodak Company, Rochester, NY. Kodak Publication No. M-8.

Eastman Kodak Company, 1984. Using Photography for Surveillance. Eastman Kodak Company, Rochester, NY. Kodak Publication No. M-10.

Siljander, R.P., 1975. Applied Surveillance Photography. Charles C. Thomas, Springfield, IL.

SUBCHAPTER 9.7

Underwater Photography

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Key Terms
Backscatter
Perishable Evidence
Refraction
Scatter
Wide-Angle Lenses

Learning Objectives

On completion of this chapter, you will be able to:

1. Understand the safety concerns that apply whenever taking underwater photographs.
2. Explain the difference between reflection and refraction and their effects on underwater photography.
3. Explain the difference between scatter and backscatter and their effects on underwater photography.
4. Explain how color is absorbed by water at different depths and the solution to this problem.

UNDERWATER PHOTOGRAPHY

Underwater crime scene photography is a vital part of underwater criminal investigations and is a challenging undertaking. Not only do you need to be a good photographer who understands the photographic challenges of an underwater environment, you need to be a skilled scuba diver as well.

Mention underwater photography, and images like those in Fig. 9.7.1 come to mind. These clear, colorful images are condition a recreational diver longs for. Fig. 9.7.1 shows views of crystal clear water, bold colorful images, and artistic compositions.

Unfortunately, these conditions are not normally experienced by the underwater crime scene photographer. Criminals tend to select locations that will hide their unwanted items, believing that no one will ever find what they threw in. Environments that are cold, dark, and deep seem to be their preferred target areas.

Underwater criminal investigations usually involve three recovery categories that need to be photographed if the conditions allow: evidence, body, and vehicle recovery.

Fig. 9.7.2A The diver is marking a sawed-off shotgun's location with a marker buoy. (B) Preparing to bag a body underwater for evidence preservation. Fig. 9.7.3 shows divers rigging a stolen vehicle with lift bags for lifting the vehicle to the surface.

Unfortunately, these recoveries are usually made and photographed in condition and environments most recreational divers would never consider diving in. Conditions such as no visibility, mud/silt bottoms, current, trash, and contamination can all be encountered on any given dive and are not only challenging, but dangerous as well.

Unlike recreational divers, underwater criminal investigators and photographers do not select their dive sites. They are called to respond to areas someone else selected for them. Some of these sites include lakes, rivers, ponds, canals, and quarries that are not normally ideal. So having the right training and equipment to succeed and survive is imperative.

Underwater Photography Training

Like land crime scene photography, it takes training and experience to master underwater crime scene photography. Start off by becoming a certified diver through a nationally recognized scuba training agency. The more scuba training and experience you receive the better and more comfortable you will be underwater. After becoming a certified diver, you can start



FIGURE 9.7.1
Classic underwater photographs.
Courtesy of Nancy Olds, Forensic Photographer, United States Secret Service.

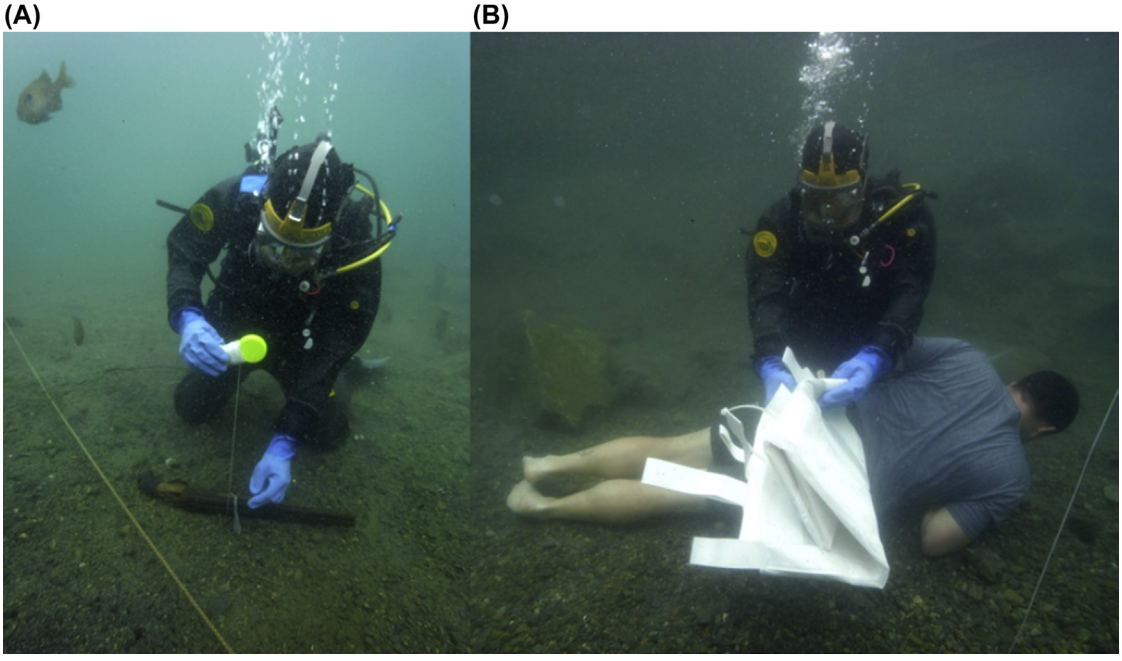


FIGURE 9.7.2
(A) Marking a sawed-off shotgun's location with a marker buoy. (B) Preparing to bag a body underwater.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/. Photo credit: Jon Coon.

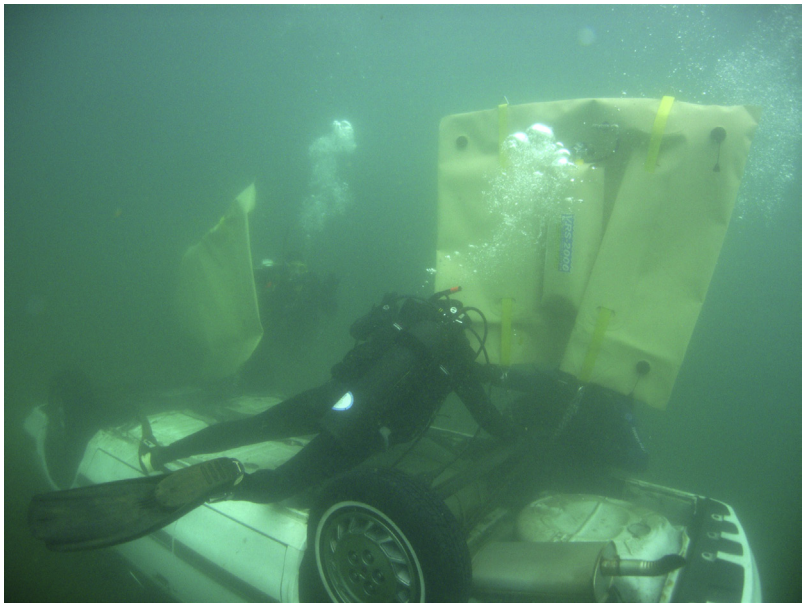


FIGURE 9.7.3
Rigging a vehicle with lift bags.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/. Photo credit: Jon Coon.

your underwater photography training by taking an underwater photography specialty course through your local dive store. Seek out a certified underwater photographer instructor with years of experience. This individual can help you in selecting the right underwater camera equipment as well as help you develop your underwater photography skills. You can also purchase a variety of underwater photography books and training videos to help you. The more training, education, and experience you have, the better your photographs will be.

Types of Underwater Crime Scene Photographs

Like land crime scene photography, underwater crime scene photography has the same three shot requirements: overall, midrange, and close-ups that need to be taken whenever possible. However, these photographs take on a new meaning due to the conditions.

For example, an overall could mean taking a photograph of an entire vehicle underwater, Fig. 9.7.4, top. A midrange would be closer up showing the person inside the vehicle, middle. And, a close-up could be of where the victim's head hit the windshield, bottom.

It is important to try to capture the vehicle and victim's condition and position prior to the divers making the recovery. Quite often the vehicle will become damaged in the recovery process and the victim's position might change during the recovery. These photographs capture the evidence as it was lying on the bottom when it was located. The land investigators get a record of the evidence as it was found which could greatly assist in their investigation. These three pictures can be taken of any evidence or scene if conditions allow.

Housed Digital Underwater Camera

A housed digital underwater camera is the preferred camera for crime scene photography and is a digital camera in a separate underwater housing. Fig. 9.7.5, left, depicts a SeaLife DC1400 Underwater Digital Camera and housing, and the wide screen and control buttons on the back of the housing.

The underwater digital camera does what a digital camera does on land. It takes and records the picture, allows you to make needed adjustments, has an attached flash to help illuminate what you are photographing, has a large LCD screen that allows you to see what you are photographing, and even allows you to record video. Fig. 9.7.5, right, is the DC1400 Digital Underwater Camera housing with Digital Pro Flash. The underwater housing protects the camera from the underwater environment, has a large LCD window so you can see the camera's LCD screen, and has large buttons that activate the camera controls. Most housed digital underwater camera systems even allow you to connect a separate flash to enhance your underwater photography.



FIGURE 9.7.4
Overall, midrange and close-up of a vehicle.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/. Photo credit: Jon Coon.



FIGURE 9.7.5
SeaLife DC1400 Underwater Digital Camera and housing with Digital Pro Flash.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/.

When it comes to choosing which underwater camera is right for you, look first at the camera's capabilities, the housing depth limitations, the control buttons' ease of use, large LCD screen, accessories, and your expected conditions.

Strobes

Underwater photography requires light, either ambient light or the light you bring with you in the form of electronic strobes. Because lighting underwater is much dimmer than when on dry land, electronic strobes will almost always have to be used to prevent underexposures. Strobes, if used correctly, can replace lost light and colors underwater and can enhance just about any picture taken. There are two popular types of underwater strobes that will do this: the attached cameras strobe and the unattached TTL (Through The Lens) automatic strobe. Let us look at each a little closer to get a better understanding of them.

- **Attached automatic strobes**: These strobes are part of the camera body and are synchronized to provide a properly exposed picture. The underwater housing has a strobe window that allows the camera's strobe to activate through it. Their disadvantage is that due to their position, you can get a lot of scattering and they do not allow for any creative lighting technique.
- **TTL Automatic Strobes**: These unite the external strobe and camera body electronically so that the camera's sensor controls the amount of flash for a properly exposed picture.

Lenses

Wide-Angle Lenses are regarded as the lenses of choice for most underwater photography because a wide-angle lens tends to make an object seem farther from the camera. Therefore, compared with a normal lens, to fill the frame with the object, you will have to get *closer* to it than when using a normal lens. Getting closer to the object means less water is between the camera and the object; therefore, there are fewer particulates to diffuse the lighting. Additional benefits include the following:

- Wide-angle lenses have better depth of field than other lens types.
- Wide-angle lenses force you to get closer to your subject when you fill the frame; therefore, with less light loss because of distance, the result is better colors.
- When you are closer to your subject matter underwater, there is less diffusion of light and more contrast in your image.
- With fewer particulates in the water between the camera and the object being photographed, **Backscatter** will be less of a problem.
- A wide-angle lens is more tolerant of the motion of the photographer because underwater currents sway their body. Of course, using a flash also helps "freeze" the bodily motion of the photographer.

Video

Video is also a great tool for the underwater criminal investigator and photographer. It is able to show everyone involved what the land and underwater crime scene looked like as well as what conditions the divers faced. Video gives the viewers a sense of "being there" and helps them better relate to the investigation.

The video you take can also be downloaded into your computer and stopped when you have the image that best depicts what you are trying to show and printed, just like a photograph. Because of this, many underwater criminal investigators use underwater video to capture their involvement.

Digital Video Camera

A digital video camera is a device that records video in different formats such as Digital8, MiniDV, DVD, an SD card, a mini SD card, hard drive, or solid-state flash memory.

A popular underwater digital video camera many underwater criminal investigators use is the GoPro camera. This lightweight HD (high definition) camera can take video as well as still images. There are many mounting brackets you can buy, including a hand held arm, helmet mount and one that mounts on the diver's full-face mask for hands free video and photography.

Fig. 9.7.6 shows two such variations. Fig. 9.7.6A shows a full-face mask rail with GoPro Camcorder and an underwater camcorder light. Fig. 9.7.6B shows a GoPro HD Camcorder with Twin Sola 1200 Video Lights.



FIGURE 9.7.6
(A) A full-face mask rail with GoPro Camcorder and an underwater camcorder light. (B) A pair of GoPro video lights.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/.

Underwater Video Lights

When buying underwater lights for your housing and camera, it is best to contact the manufacturer to see what lights they may recommend. Twin lights offer better balance and provide more light than a single light. When looking into which light to buy, consider the following:

- Battery size and location
- Burn and recharge time
- Power output
- Beam angle

Shooting Techniques

As with land crime scene photography, underwater video uses three types of shots to depict your scene. If visibility permits, getting all three for your underwater crime scene will give you a true and permanent record of how that scene looked at the time of your involvement.

- The Overall Shot: This shot usually shows the overall view of the scene. It has two main purposes—to set the stage of your crime scene and to provide a transition to a new location.
- The Mid-range Shot: This shot shows only a selected part of the total crime scene and is introduced by the overall shot. The basic uses of the mid-range shot are to identify specific evidence, to provide a transition from overall shots to close-up shots, and to serve as the main shot used in your investigation.
- The Close-up Shot: This shot is used to show details of the evidence. The overall and mid-range shots are the shots that lead your viewer to a close-up view of the main subject.

Care and Maintenance

Read the owner's manual that comes with your camcorder, batteries, lighting, and housing to find out how to care for and maintain this equipment.

Training

Like underwater photography, getting good at underwater video takes training and plenty of practice. Take an underwater video specialty course through your local dive store. A good experienced instructor can point you in the right direction and quickly get you up and running.

Underwater Light Problems

Water is approximately 600 times denser than air, so light travels through it very differently. An underwater photographer needs to be aware of water's effects on light in order to compensate for its effects to create clear photographs.

Absorption of Colors

As you descend, the water absorbs natural light and colors. The deeper you descend the darker it gets and the more colors you lose. Water acts as a filter, absorbing the different colors of "white light" at different depths. Depending on the clarity of the water, the color red will be absorbed in the first 5′ to 10′. Blue is the last color to be absorbed, which will occur at about 100′. It is not necessary to memorize which colors are absorbed at different depths. The bottom line is that the only way to ensure the capture of proper colors at any but the shallowest depths is to use electronic strobes. Because the light from an electronic flash travels much shorter distances underwater, you can be sure that the backgrounds in most of your shots will likely be green or blue if you are deeper than 25′ or so.

Fig. 9.7.7A shows the predominant green casts that will be the result of light absorption at most medium depths. At deeper depths, the only color remaining will be blue.

If you want the subject to be green or blue tinted, you would not have to use an electronic strobe. If, however, you want the proper colors of your subject to be accurately captured, you will have to use flash, as in Fig. 9.7.7B.

Scatter

Depending on the underwater location, the time of the year, the weather, and water currents, the amount of suspended particles, silt, and minute underwater organisms can vary quite a bit. Light that is reflected from objects in the water travels through this thick medium filled with floating debris; this causes the light to be scattered and diffused. Because of **Scatter**, you do not get a clear view of the subject.

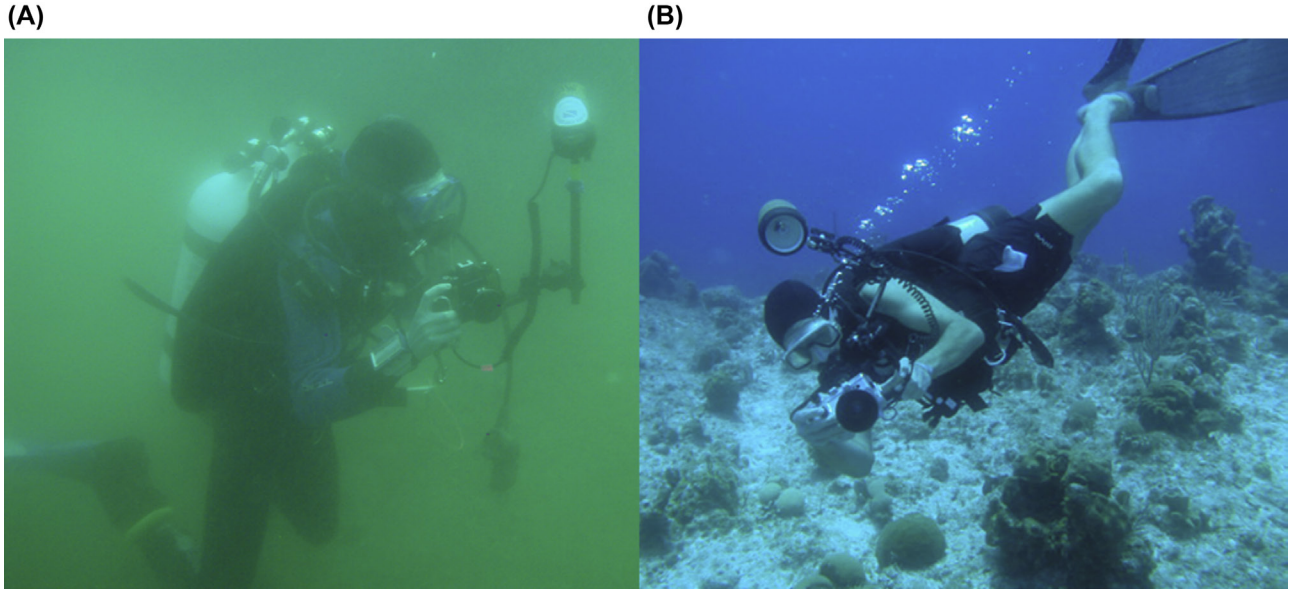


FIGURE 9.7.7
(A) Most of the world is green underwater … (B) … Unless you are deeper, where it is blue.
Courtesy of Nancy Olds, Forensic Photographer, United States Secret Service.

Fig. 9.7.8 shows just how unclear an image can be because of scatter, which can be thought of as underwater "smog." All the "classic" underwater photographs most people are used to seeing are taken in regions known for crystal clear water. Unfortunately, for underwater crime scene photographers, crystal clear water is not often encountered.

Scatter can completely block the camera from taking a good clear picture. To avoid scatter or help reduce the amount of suspended particles the camera picks up, a good underwater photographer first must master buoyancy control and have the ability to "hover" which is to hang motionless at any depth. This skill allows the diver to avoid landing on the bottom and stirring up the bottom composition which could destroy visibility and increase scatter.

Also, when the silt settles back to the bottom after a diver stirs it up, it could cover the item you are trying to photograph making it more difficult to photograph. Fig. 9.7.9 shows the silt having settled on a pistol. At least in this image, the silt is not being displaced to the extent it becomes scatter and obscures these otherwise clear images.

The following are steps to consider which will help you minimize scatter:

- Maintain proper buoyancy control (do not hit the bottom).
- Get as close as possible to your subject, which reduces the amount of particles between the camera and the subject.
- Hold the strobe off to the side or above the camera for best results.
- If possible, use two strobes, held at a 45° angle, to take out shadows caused by sediment or suspended particles.

Reflection

Reflection is when light bounces off a surface and changes its direction. This can be the sun light bouncing off the surface of the water or your strobes' lights bouncing off the item being photographed. Due to reflection, certain times of day allow better sunlight penetration than others. For example, usually the best ambient light penetration occurs on bright calm days between 10 am and 2 pm. The sun is close to being directly overhead reducing the sunlight's reflection. The more sun angle you have, the more reflection occurs and the less ambient light you have. Surface conditions also affect reflection. Calm water reflects less light. Choppy water reflects more.

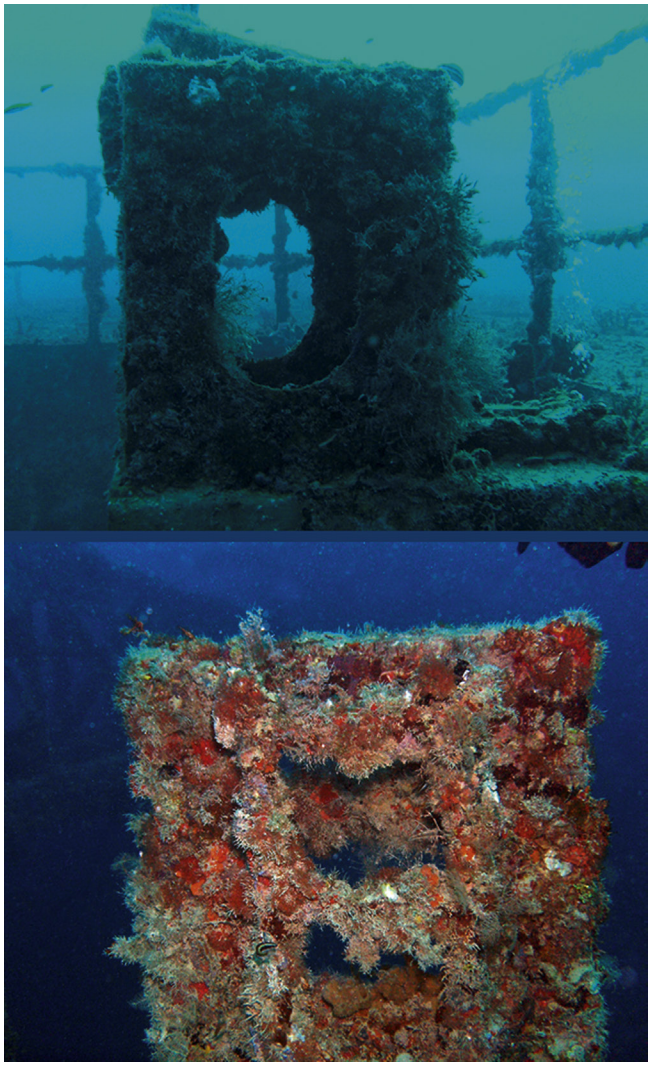


FIGURE 9.7.8
For proper colors underwater, use a strobe.
Courtesy of Nancy Olds, Forensic Photographer, United States Secret Service.

Reflection of the strobe's light can also occur from the surface of the subject back toward the camera and result in unanticipated exposures. Just as it is important to bracket when on dry land, it is also important to bracket when photographing underwater, when the lighting may be even trickier. Fig. 9.7.10 demonstrates bracketing at an underwater plane crash site.

Background Selection

An underwater photographer can sometimes choose their background to enhance the shot and evidence being photographed. Of course, the "as is" photo must be as the evidence was originally found. But, if you can recall, one of the close-up photos is an altered close-up, designed to show additional details on the evidence not initially visible "as found." In this case, we can select a different background, so that the detail of interest is most apparent.

There may be times when you can compose the shot with the camera parallel to the ground, which has the background appearing dark. Or, there will be times when you can compose the shot with the camera aimed toward the water's surface. In this case, the background can be the color of the water. Fig. 9.7.11 shows these three effects.

Fig. 9.7.12 shows a close-up photograph of a pistol taken to document that the hammer was down when the weapon was recovered. A strobe was required for proper lighting, held at an angle to reduce reflection, and bracketed for a good photograph.

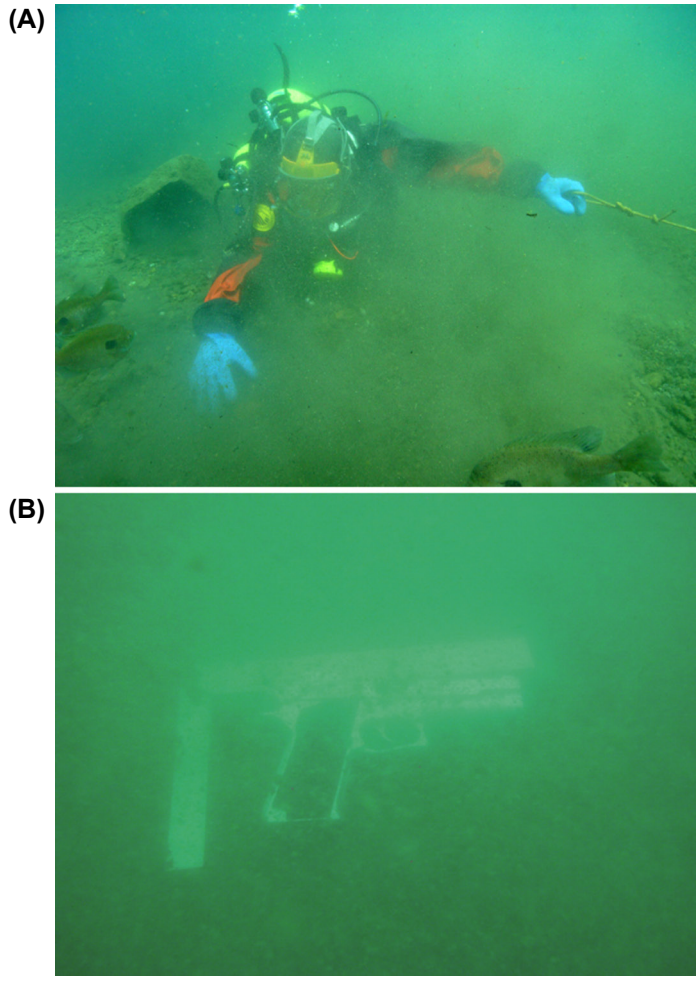


FIGURE 9.7.9
(A) Scatter *(Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/, Photo credit: Jon Coon).* (B) Thick water: Particulates in the water and bottom debris stirred up *(Courtesy of Nancy Olds, Forensic Photographer, United States Secret Service).*



FIGURE 9.7.10
Silt partially obscuring a pistol.
Courtesy of Officer Julius Wiggins, Underwater Photography Instructor, City of Miami Police Department, Retired.

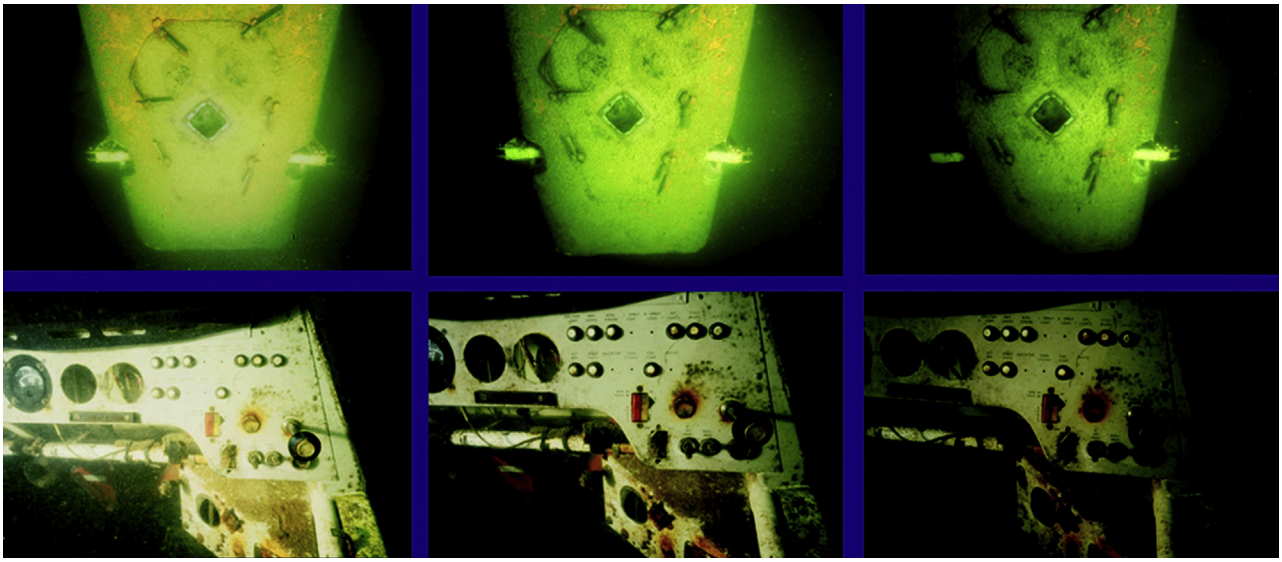


FIGURE 9.7.11
Underwater bracketing.
Courtesy of Officer Julius Wiggins, Underwater Photography Instructor, City of Miami Police Department, Retired.



FIGURE 9.7.12
Close-up photograph of a gun.
Courtesy of Officer Julius Wiggins, Underwater Photography Instructor, City of Miami Police Department, Retired.

Refraction

Refraction is the bending of light rays as they pass from one medium to another. A pencil beneath the surface in a glass of water looks both bent and magnified because of refraction, as shown in Fig. 9.7.13.

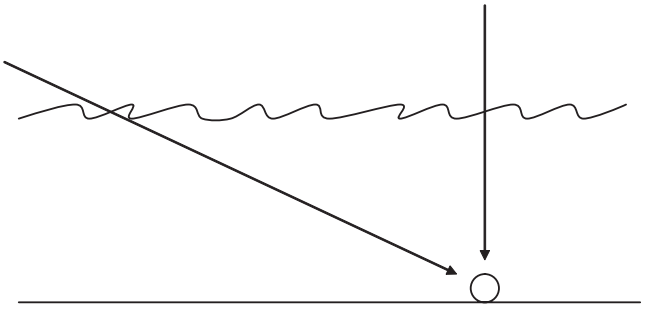
The least amount of bending occurs when the sun is directly overhead. When the sun is not directly overhead, and the light bends when it strikes the water's surface, it has to travel farther to reach a given depth, and the increased distance the light must travel also reduces its intensity (see Fig. 9.7.14).

Recall that the inverse square law stated this. Light will refract when first striking water. It will also refract when it travels through water and strikes a diver's face mask, similar to when light travels through water and strikes the lens cover of an underwater camera in a protective underwater housing. Refraction is the phenomenon that makes underwater objects, viewed through either normal flat camera lens covers and flat diving masks, appear approximately 25% closer than they really are.

Refraction creates two underwater problems for photographers due to its magnification. If an object appears to be at distance "x" from you, but you know it is really at distance "y" from the camera, then how do you focus, and where do you aim the flash?



FIGURE 9.7.13
Refraction bending and magnification of a pencil.



Direct light from above has a shorter distance to travel to light an object. Light coming from a low early morning or late afternoon sun has to travel farther through the water to light the same object, making the light dimmer once it finally reaches the object.

FIGURE 9.7.14
Refracted light, traveling farther, is dimmer when it arrives.

Because the camera "sees" like your eyes do, focus on the apparent distance of an object underwater, which will actually be closer than the object really is; focusing on the true distance will result in out-of-focus photos. However, it is necessary to aim the strobe at the object's actual distance. Fig. 9.7.15 graphically demonstrate both of these concepts.

One solution to the apparent magnification of underwater objects is to use an underwater camera housing with a domed port that covers the camera lens. The use of a domed port over the camera lens "corrects" the distance distortion, and objects appear at their true distance. These are much more expensive than the normal flat ports of an underwater camera housing.

The flat port, is most commonly used for underwater photography, but the "purists" may prefer the domed port variations, as shown in Fig. 9.7.16.

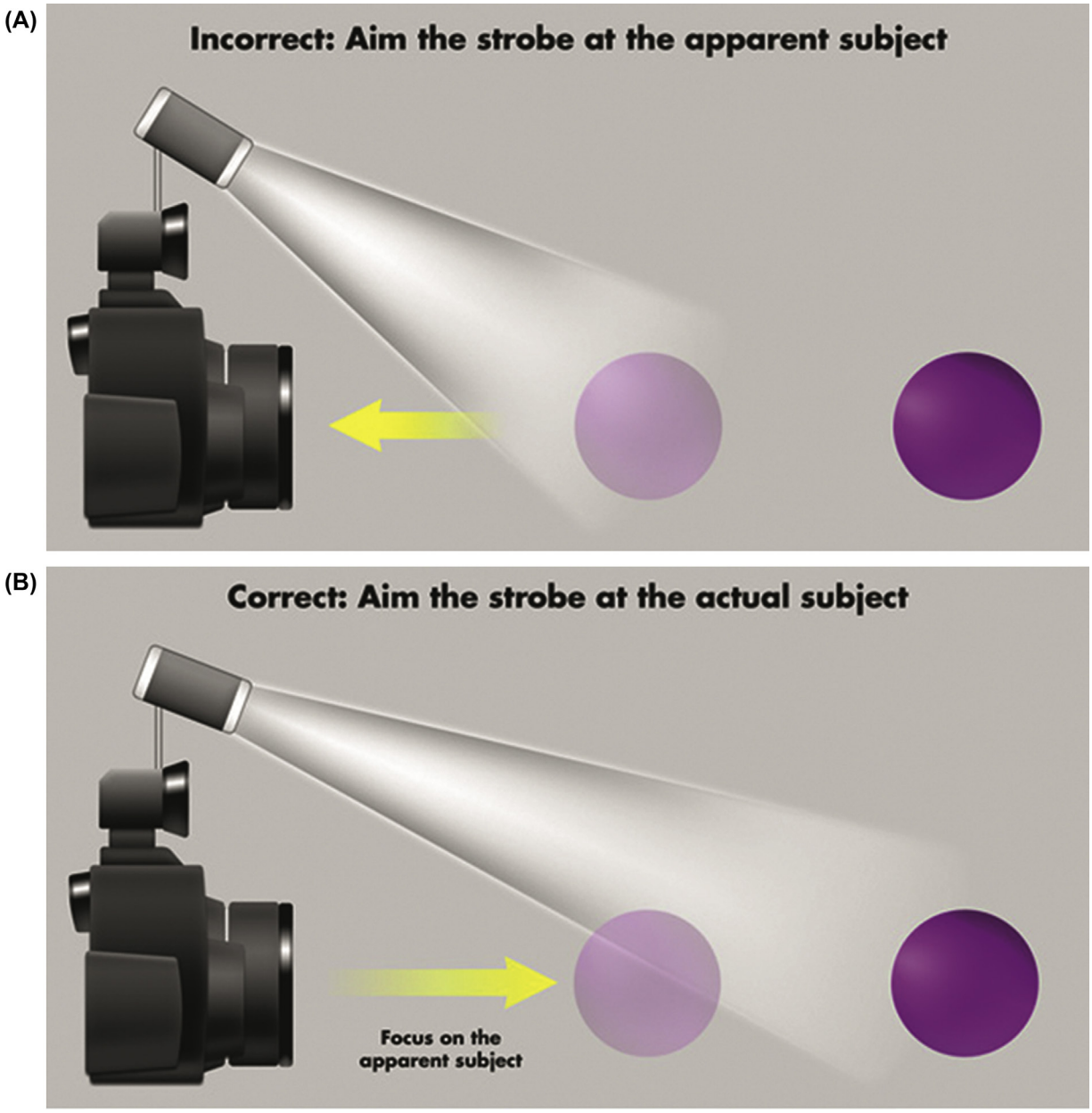


FIGURE 9.7.15
(A and B) Focus on the apparent distance; aim the flash at the actual distance.
Courtesy of Jeff Robinson, Graphic Artist, http://www.scamper@scamper.com.

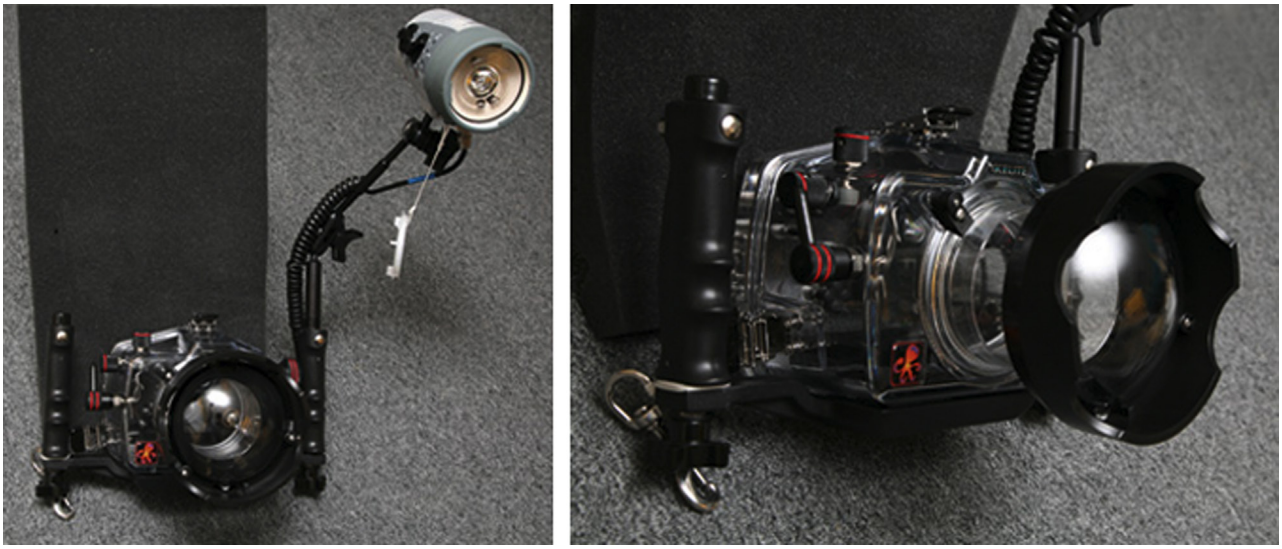


FIGURE 9.7.16
Underwater camera housing, domed port.
Courtesy of "Dori" Charmichael, Splash Dive Center, Inc, Alexandria, VA.

Backscatter

Remember the last time you drove through fog at night and how the light from your headlights bounced back and you could hardly see. Suspended particles caused by microscopic organisms, stirred sediment, and so on can cause the same effect and obstruct the view to the subject being photographed. When using a flash, the light from your flash can bounce off these suspended particles and bounce back into the lens causing bright spots between the flash and the prime subject matter (like snow). This effect is called "backscatter."

Fig. 9.7.17 shows various degrees of backscatter obstructing the view of a sunken boat. The top image was captured with the flash held at the camera's position. This is the worst position for the flash when it is obvious there are many particulates in the water. The lower image shows that if the flash does not strike the particulates directly from the camera's position, the appearance of backscatter is less evident. This lower image is a result of holding the flash as far away from the camera as you can.

Because backscatter is not a desirable feature of photographs, is there a way to avoid it? To avoid backscatter, keep your light source as far away from the camera as possible and light your subject from an angle of approximately 45°.

Figs. 9.7.18 and 9.7.19 show the theory and the practice of backscatter causation and avoidance. Bounce light off the front of the suspended particulates in the water, and the result is underwater "snow." Remove the flash from the immediate area of the camera, and the side lighting of these same particulates minimizes their appearance.

Special Note: Nick Oliver, a former graduate student at The George Washington University, took the images in Fig. 9.7.19. This is a perfect opportunity for a bit of unabashed institutional self-promotion.

Photographer Getting Into the Water

Now that you have a good understanding of the training and equipment that might be needed for an underwater crime scene photographer, you may be wondering at what stage of the investigation this individual gets into the water. It is after the evidence has been located and its position marked. After the bottom has had time to settle down (due to dives stirring up the bottom) the photographer would then enter the water and follow the search line or marking system to the evidence, taking care not to stir up sediment and reduce the visibility. Hovering over the item, the photographer would take his/her photographs.

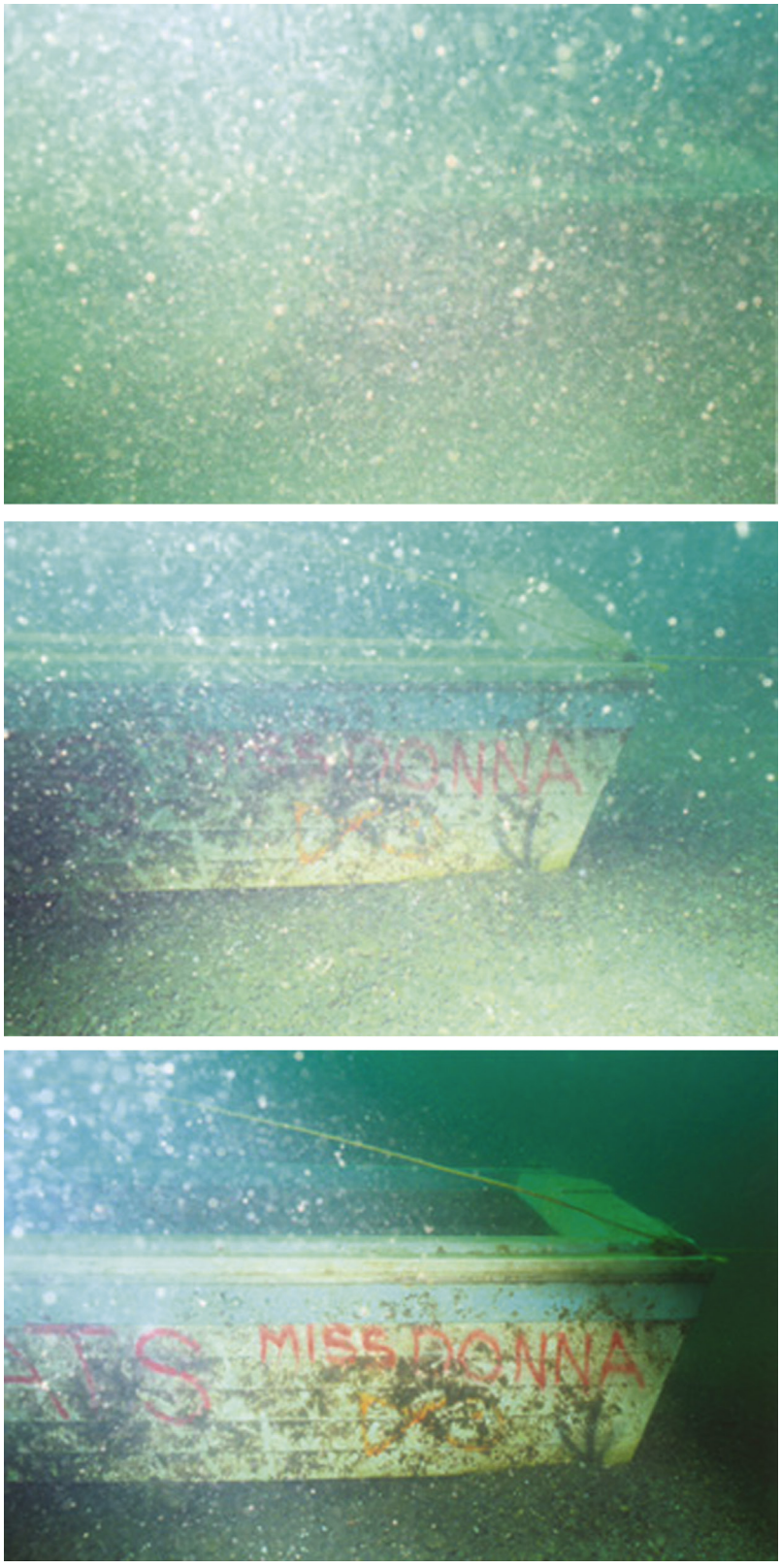


FIGURE 9.7.17
Various degrees of backscatter.
Courtesy of Nancy Olds, Forensic Photographer, United States Secret Service.

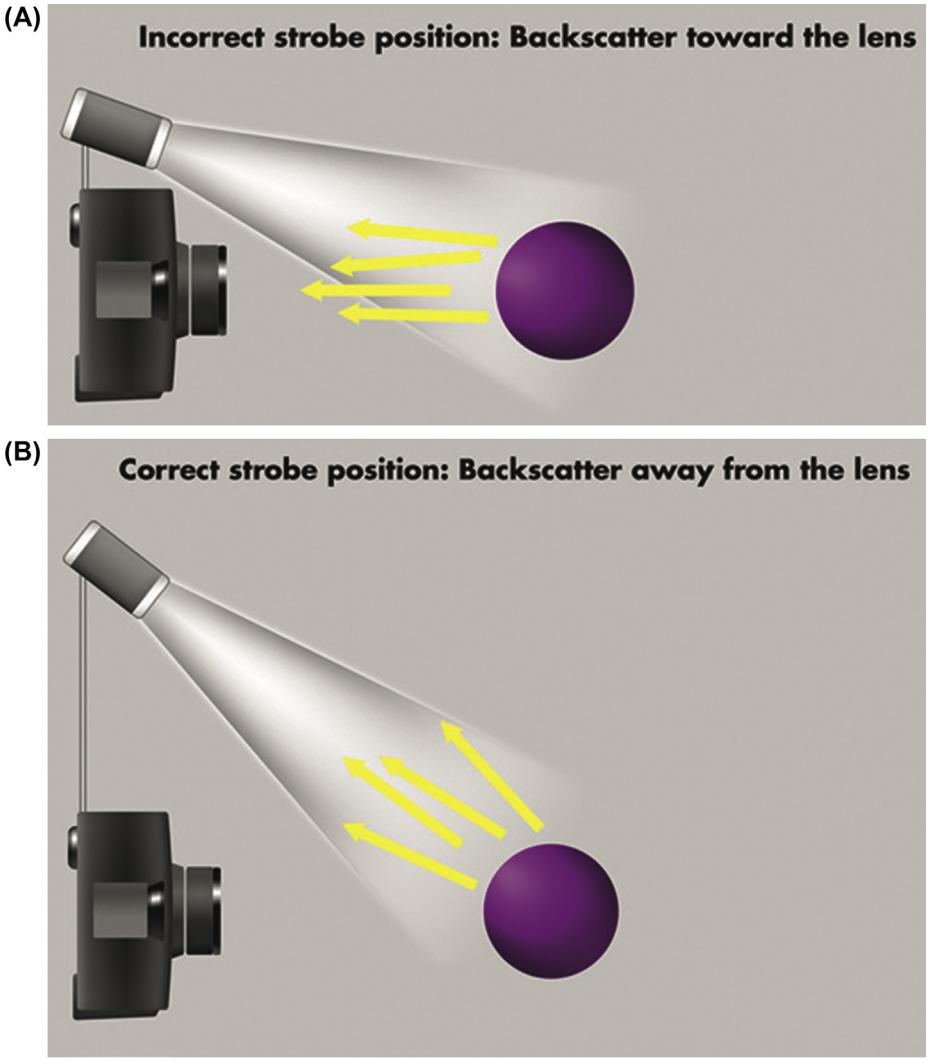


FIGURE 9.7.18
(A) Direct flash. (B) The flash removed from close proximity to the camera.
Courtesy of Jeff Robinson, Graphic Artist, http://www.scamper@scamper.com.

Safety Concerns

Being involved in an underwater criminal investigation by being asked to participate as the underwater crime scene photographer can be quite an honor. Using your diving skills as well as underwater photography skills to assist in documenting a crime can be challenging as well as rewarding. Keep in mind, though, the hazards that can be present. Operating in low visibility, harsh conditions like deep, cold water, and always facing the possibility of contaminated water and unforeseen hazards that await you down below should keep you on your guard. The requirement to document evidence underwater cannot supersede the diver's safety. Safety is always first. Always be aware of your surroundings, depth and air supply. The underwater environment is inherently a dangerous location.

The following are a few suggestions to keep you safe:

- Conduct a good equipment check prior to getting into the water.
- Dive only with a partner. The buddy system works and saves lives.
- You should constantly monitor your air supply.
- The additional weight and drag of the equipment are fatigue factors important to remember.
- Do not use a camera neck strap. Instead, consider using a wrist strap that you can easily slip free from if it becomes entangled in underwater debris.



FIGURE 9.7.19
Direct flash and the flash removed from close proximity to the camera.
Courtesy of Nick Oliver, GWU MFS student.

Underwater Criminal Investigators

Nothing can take the place of having highly trained and certified Underwater Criminal Investigators (UCI) on hand that you can call upon when your criminal investigation leads to the water's edge. These individuals are highly trained divers who specialize in conducting criminal investigation in an underwater environment.

Fig. 9.7.20 shows two UCI divers in training conducting a "Jackstay" search pattern which is a movable underwater grid pattern. Divers holding hands, move along the search pattern searching the area in front of them. When they get to the other end, they move the pattern over and search back and repeat the process.

When the area of interest is smaller, actual grids can be made and moved along an artificial baseline which has been created with a temporary fixed line. Fig. 9.7.21 shows this.

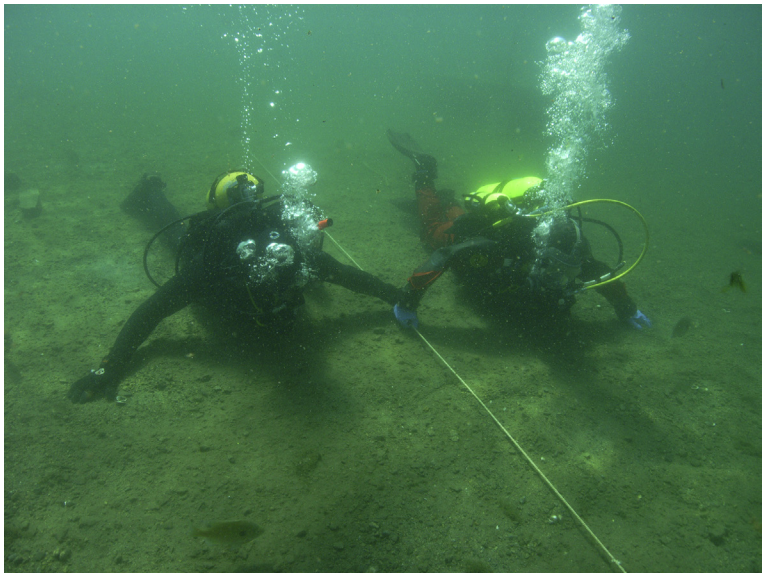


FIGURE 9.7.20
The "Jackstay" search method.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/. Photo credit: Jon Coon.

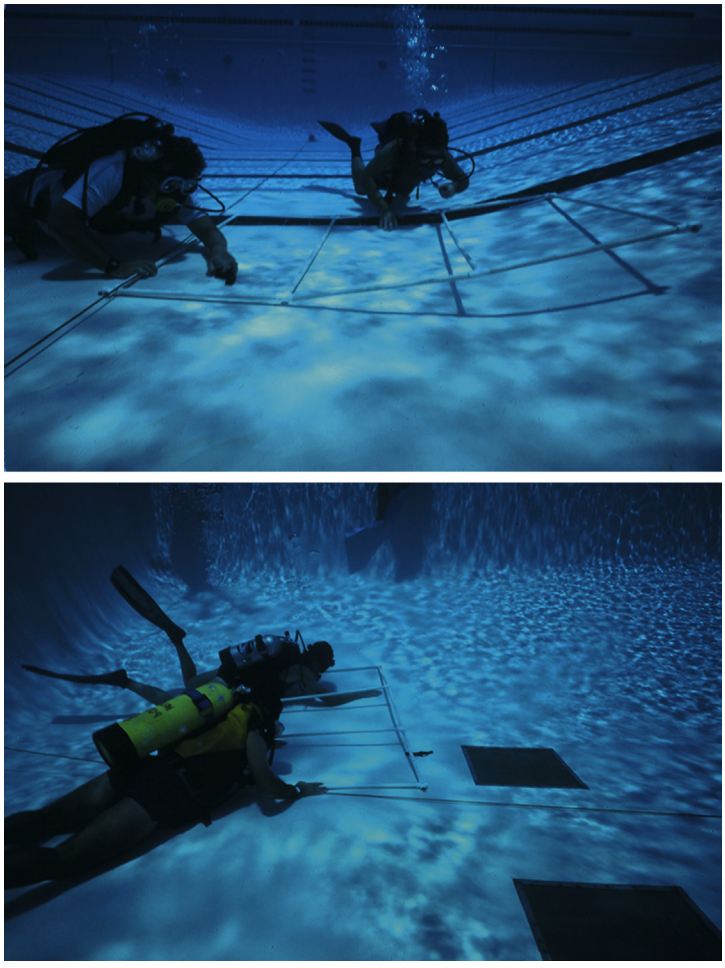


FIGURE 9.7.21
Gridding the evidence.
Courtesy of Officer Julius Wiggins, Underwater Photography Instructor, City of Miami Police Department, Retired.



FIGURE 9.7.22
Packing a knife in the same water as found.
Courtesy of Michael Berry, Virginia State Police, http://www.ucidiver.com/. Photo credit: Jon Coon.

Fig. 9.7.22 shows a UCI diver packaging a knife after it has been located, marked, and documented. It is important to remember that if a metallic item of evidence is removed from the water, it can begin to rust. Keeping it in the same water it is found in can help preserve it. Knives, handguns, long guns, and any other type of evidence with is metallic will benefit from this. And, depending on your agency's SOPs, before packing a firearm in the water it is found in, the UCI may be required to have first unloaded it and "made it safe" before turning it over to anyone else.

A UCI diver adapts many of the same techniques used on land to capture the same professional images underwater. Fig. 9.7.23 shows a camera on a quad-pod, capturing images of interesting evidence.

GWU's First UCI Graduating Class

Several years ago, a group of enterprising students asked if there was any opportunity to obtain credit toward the Master of Forensic Science degree for work done relating to underwater crime scene searches and underwater photography. The idea did seem to align with the Independent Research Course, where students could take any aspect of core curriculum courses and delve deeper into that subject matter. Their idea also seemed a perfect marriage of the Crime Scene Investigation and Forensic Photography courses. Two stipulations were mandated. They would have to first become SCUBA certified, if they were not already so certified. We contacted the Splash Dive Center in Alexandria, Virginia, to facilitate this. Then, they would have to pass the Underwater Criminal Investigators (UCI) course taught by First Sergeant Mike Berry, a Virginia State Trooper and highly regarded national diving instructor (http://www.ucidiver.com/). Having passed those two hurdles, the students would then write a term paper relevant to their training.

Fig. 9.7.24 shows George Washington University's first UCI graduating class, with Mike Berry. Their final dive was in the James River, adjacent to Richmond, Virginia, where they recovered a rifle that had not been planted for the occasion.

The International Association for Identification certifies both crime scene investigators and forensic photographers. It makes sense that the certification of underwater criminal investigators should also be done. Of course, SCUBA diving is a great hobby. Underwater crime scene search and evidence recovery, however, should not be left to the hobbyist.



FIGURE 9.7.23
Camera on a quad-pod.
Courtesy of Officer Julius Wiggins, Underwater Photography Instructor, City of Miami Police Department, Retired.



FIGURE 9.7.24
George Washington University's first graduating class of underwater criminal investigators.
Courtesy of Sergeant Mike Berry, Virginia State Police; Amie Balle and Elizabeth Toomer, GWU MFS students.

SUMMARY

Underwater photography is potentially dangerous and presents unique problems that have to be solved. The issues encountered with underwater photography and the solutions to these problems are covered in this chapter.

DISCUSSION QUESTIONS

1. Indicate some safety concerns related to underwater photography.
2. Effectively lighting underwater objects with electronic flash differs from using a flash on dry land. What are the main issues and solutions?
3. How can you be sure the colors of underwater objects are accurately captured?

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SUBCHAPTER 9.8

Vehicle Crash Photography

Marc Hackett
Arlington County Police Department, Arlington, VA, United States

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the two most critical elements involved in photographing a vehicle crash scene.
2. Explain why prioritizing perishable evidence is important at vehicle crash scenes.
3. Explain noncritical priorities at vehicle crash scenes that usually require early attention.
4. Explain how to photograph the approach to the actual vehicle crash scene.
5. Explain the necessary photographs required to adequately photograph the roadway or the surface of the vehicle crash scene.
6. Explain the required photographs to photographically document the vehicles involved in the crash.
7. Explain some additional concerns when photographing injuries to drivers and occupants of the vehicles involved.

VEHICLE CRASH PHOTOGRAPHY

According to MPO Marc Hackett of Arlington County (VA) Police Department, the term "Accident Photography" should actually be labeled "Vehicle Crash Photography." The word "accident," according to the Merriam-Webster's Dictionary, is defined as "an unforeseen and unplanned event or circumstance" or "an unexpected happening causing loss or injury which is not due to any fault or misconduct on the part of the person injured but for which legal relief may be sought." These definitions of "accident" do not include intentional acts such as homicide, manslaughter, assault and battery, and fraud. When we think of an "accident" these do not come to mind, but when we use the phrase "vehicle crash," we are using a broader term. This allows for the investigator to keep a more open mind when completing the entire investigation. As it has been said, all death scenes are treated as homicides until proven otherwise. Thus, we will not overlook something or miss something. This also goes for vehicle crashes if you treat them as true crime scenes and not as accident scenes; we should not overlook anything.

INITIAL PRIORITIES

Two Critical Elements

If the layman was asked the first job requirement of a law enforcement officer at a major vehicle crash scene involving injuries, the most frequently offered answer would probably be to render aid to the injured. Although certainly important, because the survival of critically injured parties is at stake, one responsibility is even more critical: that is, to protect the vehicle crash scene itself. It does not benefit the injured crash victim, the officer, or the general public if conditions are left so that another crash can occur. Even worse would be allowing a situation to exist where another vehicle was able to drive into the original vehicle crash scene while the officer was rendering first aid to the first crash victim. Then the first crash victim and the officers present at the scene are imperiled. This can be regarded as this chapter's first Rule of Thumb.

RULE OF THUMB 9.1

The first responsibility of a law enforcement officer has to be to protect the vehicle crash scene itself so that no further crashes can occur.

Frank Carson, Prince Georges County (MD) Police Department accident reconstructionist, offers these additional thoughts regarding this idea. If the roadway has to be shut down, or even if just some lanes have to be closed, make sure dispatchers for the police department, fire department, and any other emergency services are notified. Carson

has had police chases, fire trucks, and ambulances run through crash scenes he had been working. Even when cones, flares, and charley-horse barricades have been put out to divert traffic, cars will still drive into your scene. Prepare for the worst and wear a good reflective vest to remain visible under all conditions.

After the vehicle crash scene has been protected, the responsibility to render aid to the injured becomes paramount.

Prioritizing Perishables

Once the scene has been stabilized and the injured have been dealt with, the next most important responsibility is to protect **Perishable Evidence** from being lost or destroyed. Frank Carson reminds us that this means more than just evidence related to the crash.

Some evidence may remain at the scene for long time periods and still retain its full value as evidence. Other types of evidence are fleeting or highly perishable and need to either be collected as soon as possible, protected to avoid loss or change, or documented one way or the other. Three primary types of *perishable evidence* exist.

Evidence Subject to Inclement Weather

Bad weather can destroy evidence. It can be washed away in the rain, it can be blown away by the wind, it can be covered up by snow, and moist tire tracks can evaporate. The initial law enforcement officers at the scene have a responsibility to protect these types of transitory evidence as best as they can. That may mean covering such evidence with something. (Some have suggested putting a garbage can lid over the evidence to keep it from being blown away. That idea may initially sound good until you consider what may be on the inside of the garbage can lid! Contamination is frequently used as a reason to exclude evidence in court!) Or, it may mean that a traffic cone must be placed over them. Some affirmative action must be taken to preserve this fragile evidence somehow. If it is fleeting, it will need to be documented as soon as possible by photography and measurements.

Evidence in the Path of Travel

Some evidence may be lying in the roadway in a position where other traffic may destroy it. This may be ordinary traffic trying to make its way around the vehicle crash scene, or it may be other vehicles operated by rescue personnel or other law enforcement officers responding to assist at the vehicle crash scene. In either case, the initial officers at the scene have the responsibility to protect this evidence also. Traffic may have to be directed around this evidence until it can be documented by photography, measured, and collected. Treat this like a crime scene so evidence is not lost or destroyed.

Evidence Subject to Biological or Physiological Processes

If a driver is under the influence of alcohol or drugs, both of these forms of evidence will diminish over time by being metabolized. The presence of alcohol or drugs in the driver must be documented as soon as possible with appropriate field tests and then later with confirmatory tests.

And, the deceased are subject to a variety of early physiological changes that need to be documented because in a short time they will exhibit different characteristics.

Noncritical Early Priorities

The next most important issue after prioritizing perishable evidence is to attempt to reestablish the traffic flow. The crash may be tragic to those involved, but many others are affected by it, and it is said, "Life goes on." Alternate traffic lanes around the actual crash have to be established, or detours have to be determined.

Besides reestablishing the traffic flow, law enforcement officers must consider one other matter before beginning the actual business of working the crash. People may be gathering to look at the effects of the crash. "Rubberneckers" may slow traffic, but pedestrian onlookers may actually make the investigation of the crash even more difficult. Well-meaning, but naïve, onlookers have actually collected evidence scattered around the scene, trying to be helpful, and have then turned in their evidence to law enforcement personnel at a later time. Some evidence can become someone's souvenir and will never be seen again.

Therefore, it is imperative to safeguard the vehicle crash scene from the crowd sure to gather around any serious crash. The use of police banner-guard is the normal means by which off-limit areas are marked. Police cars can block streets, charley-horse blockades can be placed as needed, and officers physically positioned to direct pedestrian and vehicular traffic can all be used to meet this need.

The Vehicle Crash Scene

THE APPROACH TO THE SCENE

As with crime scenes, it is easy to get too focused on the actual impact site, with the damaged cars, and the injuries to the occupants of the vehicles. Although the impact site is certainly important, overall aspects of the scene are usually just as important in determining what happened and why. For each vehicle involved in the crash, it is necessary to document the approach to the scene. To do this effectively, the investigator might need to backtrack each vehicle's approach to the actual crash scene by several blocks. It is possible for a driver to lose control of a vehicle several blocks before an actual impact occurs. Sometimes the "cause" of the vehicle crash is not near the actual crash scene.

TRAFFIC CONTROL DEVICES

The photographer may be required to include photographs several blocks away from the actual site. It will be necessary to begin the documentation of the approach to the crash site from a position that includes all the traffic control devices that should have controlled the driving behavior of each driver, or pedestrian, in the crash (see Fig. 9.8.1). These concerns include the following:

- Speed limit signs
- Lane control lights, signs, or painted lane markers
- Stop, yield, or other caution signs
- Bridge height indicators
- School warning signs
- Pedestrian crosswalk signs
- Red, yellow, and green traffic lights
- Railroad crossing warning signs

and so on.

This distance may be as little as 100′ from the point of impact, or it may involve moving beyond sight of the actual impact area. This will vary with the vehicle crash. Frank Carson reminds us that a vehicle moving at 60 mph is traveling at 88 feet per second. In the 5 s prior to the crash, that car has traveled 440 feet. It may be necessary to backtrack that distance, or farther, to adequately document the causes of the vehicle crash.



FIGURE 9.8.1
Traffic control types.
Courtesy of the Arlington County Police Department, VA.

Weather Conditions

Sometimes the immediate site of the vehicle crash does not adequately represent the actual weather conditions that influenced traffic as the vehicles approached the crash scene. Snow, for instance, may have melted from some areas of the highway but still be present in other areas. Wet pavement, in combination with oil residues on the highway, may have made a particular section of the roadway slick. A vehicle may have begun to lose control and begun swerving several hundred feet away from the ultimate impact site, but it is not until the approach to the scene is examined that this is discovered. Portions of the highway may be icy, although the actual crash scene may be free of ice. If no one survives the crash and to report what happened to investigators, it is up to the investigator to examine the entire "scene," and this may include areas out of sight of the actual impact location. Again, it is important to resist the urge to get too focused just on the immediate accident site.

View Obstructions and Sight Distances

Assuming the individual drivers were driving diligently:

- What could they have been reasonably expected to see?
- When could they have seen it?

These two critical questions are often asked of professional accident reconstructionists. The elements of time, distance, and speed calculations are used in conjunction with view obstructions. These concerns may necessitate a return to the scene at a later point for additional photographs and measurements, but these same concerns should be present in the mind of the photographer taking the original photographs. As mentioned previously, the scene photographer may not have the necessary training to figure out the precise positions of each driver at the:

- Point of possible perception
- Point of actual perception
- Point of no escape

However, being aware that view obstructions are critical factors in many vehicle crashes, the scene photographer can attempt to take photographs at several points along the approach to show the visibility of the overall scene each driver might have had.

With these types of photographs, it is important to also remember that the drivers were probably positioned differently than a standing photographer. The driver in the seat of a tractor trailer has quite a different sight line than the driver in a small sports car.

RULE OF THUMB 9.2

Efforts should be made to take photographs from the eye level of the drivers involved.

Witnesses' Viewpoints

Not only are the sight lines of the drivers involved in a vehicle crash of importance but also the positions of any witnesses who may be available. An important aspect of many trials is whether witnesses could have seen what they said they saw from the position they were in at the time of the vehicle crash. Therefore, it is just as critical to determine the position of witnesses and their viewpoints. Were they also in a vehicle, pedestrians on the sidewalk, or did they view the vehicle crash from a second floor window? Photographs should be taken from these positions as well. It may be wise to also take a photograph from the vehicle crash scene looking toward where the witness was supposed to have been. This photo may help clarify whether the witness had a clear view of the vehicle crash scene. The use of panoramic photography techniques may be used to show the full view of a witness location shooting at the same eye level as the witness. If you have to come back during a different time in a heavily traffic area, then the use of neutral density (ND) filters could be used to grasp the actual scene without showing the moving cars. Why? ND filters block up to three stops of light, allowing the shutter speed to be slowed down three stops. This may be all that is necessary to make moving cars "disappear."

The Actual Vehicle Crash Scene

Temporarily ignoring the vehicles and occupants of the vehicles, what are some of the most frequently found types of evidence at vehicle crash scenes?

Tire Marks

Even if you are not an accident reconstructionist and able to interpret the tire marks at an vehicle crash scene, it is still obvious that they are important, and it is important to photographically document them. Whether they are skid marks, scuff marks (marks usually narrower than the tire is wide, and leaving marks with stria diagonal to the outside edge of the tire mark), impact scrubs or offsets (indicating the point of impact), or any other kind of tire marks, they may be crucial to determining exactly what happened at the vehicle crash scene. Fig. 9.8.2 shows examples of a side and scuff mark. A skid mark is usually the full width of the tire, and leaves marks with stria parallel to the sides of the tire. It is made when the tire is locked and not rotating, either from breaking or damage. A scuff mark is usually narrower than the tire is wide, and leaves marks with stria diagonal to the outside edge of the tire mark. The tire is still rotating as the vehicle "fishtails," frequently because the vehicle is going too fast for the turn. A scuff mark is also known as a critical speed yaw mark.

Fig. 9.8.3 shows a collection of miscellaneous tire marks.

There may be times when making sense of the tire marks and interpreting their full meaning may not be easy when working from the ground. At major vehicle crash scenes, if your agency has the ability to get aerial shots of the vehicle crash scene, seeing the scene from above may be a distinct advantage. Fig. 9.8.4 includes two views of a vehicle crash scene: from the ground and an aerial view.



FIGURE 9.8.2
Scuff and skid marks.
Courtesy of MPO K. Ahn, the Arlington County Police Department, VA.



FIGURE 9.8.3
Skids, scuffs, and impact scrubs.
Courtesy of the Arlington County Police Department, VA.

Recall that when the sun is out, a polarizer filter may be useful for imaging the full length of tire marks. Sun glare may wash out some of the tire marks, including the "shadow" marks at the beginning of skid marks. Carson mentions that if you can return to the scene when the sun is low in the horizon, either early in the morning or late in the afternoon, the marks may be easier to see. At night, lighting the tire marks from a low angle is optimal. Well-meaning officers, lighting the tire marks with their spotlights in an attempt to be helpful, can unintentionally obscure the tire marks.

Normally, four views of each tire mark will be needed:

- From one of the ends, down its length, to show the directionality, which is often best done with the photographer viewing the roadway parallel to the side of the road. Remember to use a normal lens to avoid distorting the length of the tire mark or the accident scene. Sometimes, according to Carson, the beginning of the tire mark is not obvious, so consider placing a marker at the beginning and end of the tire mark in these photographs. Tire marks on wet pavement may be difficult or impossible to see. Consider returning when the pavement has dried to document these tire marks. Carson advises that aerial views of a complex vehicle crash scene may make the interpretation of difficult-to-see and overlapping marks easier.
- Another view from the other end. Again, parallel to the side of the road.



FIGURE 9.8.4
Aerial views may make the tire marks easier to understand.
Courtesy of Frank Carson, Prince Georges County (MD) PD accident reconstructionist.

- A third photograph of the length of the mark should be made as viewed from perpendicular to the side of the road. This shows the side view of the tire mark in relation to the side of the roadway, but this may not necessarily be the best view of the tire mark to show its true length. The tire mark may be diagonal within a lane.
- A final view of the length of the tire mark from the true side of the tire mark, not from the side of the roadway, to show its length from the best position, which is a view of the tire mark with the film plane parallel to it.

Material on the Roadway

Often a critical element of the vehicle crash may be the preexisting condition of the roadway itself. It may have:

- Defects: potholes or bumps in the road
- Contaminants: gravel, sand, dirt, leaves, oil
- Weather-related problems: snow, ice, sleet, rain

These conditions all need to be carefully photographed as possible contributing causes of the vehicle crash.

MARKS IN THE ROADWAY; DEBRIS ON THE ROADWAY

During the crash, the vehicles will frequently leave marks on the roadway. There may be gouges, scrapes, or tire tracks in the soft shoulder of the road. Marks like these are frequently used to determine the path of travel of each vehicle, or the actual point of impact, when the energy from the impacting vehicles forced them down into contact with the pavement.



FIGURE 9.8.5
Marks and debris in the roadway.
Courtesy of the Arlington County Police Department, VA.

The impact between vehicles may also have knocked off dirt from the undercarriage, effectively positioning the vehicles at impact. During the vehicle crash, glass may have broken, paint may have chipped off, vehicle fluids may stain the roadway, and vehicle body parts may have broken off. The positions of each of these types of evidence can help determine the positions of the vehicles at the point of impact and afterward as they came to final rest. This type of evidence must be both photographed and measured for the vehicle crash scene diagram (see Fig. 9.8.5).

OTHER DAMAGE

Part of the documentation of the accident scene may be to show the damage to guardrails, sign posts, utility poles, trees, bushes, fences, and so on (see Fig. 9.8.6). Not all accidents remain neatly on the roadway. Vehicles have even struck buildings after leaving the roadway.



FIGURE 9.8.6
Damage to other property.
Courtesy of the Arlington County Police Department, VA.

VEHICULAR DAMAGE

Mid-range photographs of each vehicle must be taken to show them in relation to the fixed features of the vehicle crash scene itself. They should also be photographed as viewed parallel to the roadway edge and perpendicular to it. Then the vehicles have to be photographed to show their relationship to each other, whether they are still in contact with each other, or have separated from the force of the accident.

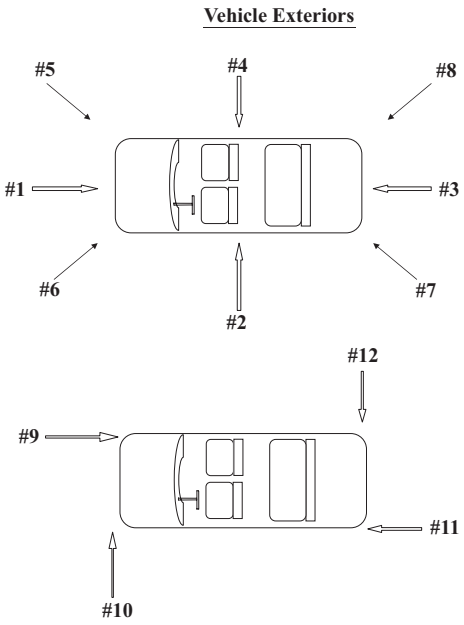
To adequately document the damage to the vehicles involved in the accident, these kinds of photographs are often required.

VEHICLE EXTERIOR AND INTERIOR VIEWS

Sometimes, "damage" to another side of a vehicle may later become an issue in a trial when one driver claims to have been struck by another "phantom" motorist, lost control, and then caused the crash at issue (Dubois, 1993). To prove that this was not the case, complete exterior photographic documentation is required, as shown in Fig. 9.8.7. Then it can be visually proven that there is no other damage to the vehicle in question to corroborate or refute such alibi attempts.

RULE OF THUMB 9.3

It is just as important to document the obvious damage as it is the areas of the vehicles that are not damaged.



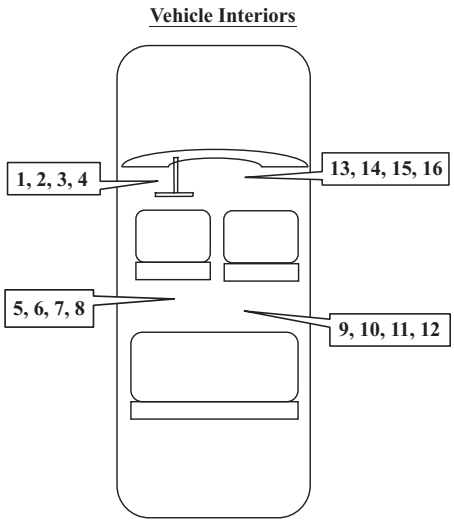
Vehicle Exteriors:

1-4: All four sides of the vehicle, even if there is no apparent damage to any side.

5-8: Damage to any of the corners. These are to be done only if that particular corner is damaged.

9-12: Photos down the side of the vehicle. These are to be done only if that particular side shows crush damage. These are to assist the accident reconstructionist determine speed from crush.

13. The exterior of the vehicle photographed from straight overhead, if possible.
14. The undercarriage, as necessary.
15. Any damage to the wheels and tires, including indications of skidding, wear, or puncture.
16. License plates.
17. Paint transfers.
18. Vehicle lamp filaments. Caution, these may be very fragile, so consider photographing them in place before removing them.
19. Detached vehicle parts.



Vehicle Interiors:

1. Driver's seat.
2. Driver's floor.
3. Left side of instrument panel; windshield, including the steering wheel.
4. Left front door and interior panels.

5. Left rear seat.
6. Left rear floor.
7. Right front windshield header; right front A-post.
8. Left rear door and interior panels.

9. Right rear seat.
10. Right rear floor.
11. Left front windshield header; left front A-post.
12. Right rear door and interior panels.

13. Right front seat.
14. Right front floor.
15. Right side of instrument panel; windshield.
16. Right front door and interior panels.

17. Obvious damaged areas, which may have contributed to the injuries of occupants.
18. Seatbelts, to indicate if they had been worn by occupants or not.
19. Any air bags which had deployed. It may also be valuable to show that a particular airbag did not deploy.
20. Vehicle Identification Number.
21. Pedals: brake, clutch, accelerator. A shoe tread pattern may be visible on them; or, the pedal pattern may be visible on the shoes or bare feet of an occupant, indicating they were the driver.
22. Speedometer dial, for possible needle impact point visualization. This may require fluorescent photography.

FIGURE 9.8.7
Vehicle exterior and interior photographs.



FIGURE 9.8.8
Vehicle damage, including an image from above.
Courtesy of Frank Carson, Prince Georges County (MD) PD accident reconstructionist.

Frank Carson also suggests a photographic view of damaged vehicles from directly over the vehicles. At times, the only way to adequately show the depth of the damage is to image the vehicle from above. Measuring sticks or tape measures laid parallel to the sides of the vehicle may help (see Fig. 9.8.8).

To the extent possible, these photographs should be taken before the vehicles are moved. Often, this may not be practical because of rescue operations attempting to remove the injured who may be trapped inside the vehicles. Crash damage should be distinguished, whenever possible, into one of these categories:

- Damage from the vehicle crash
- Damage from rescue activities
- Damage from moving/towing operations

Photographers and accident reconstructionists not present at the original crash scene have to try to distinguish between these various types of damage. Only adequate photography and proper note taking can provide this information.

In addition to the preceding recommended photographs, particular attention should be paid to the following:

- Tires: Damaged, worn, signs of skidding, and pattern type (see Fig. 9.8.9).
- License plates and vehicle identification numbers (VINs). Documenting the VINs is important because at times a vehicle has no license plates at all, and sometimes the plates that are on the vehicle do not belong to it. Often, tracking the true owner of the vehicle can then only be done through use of the VIN. Phil Sanfilippo, Training



FIGURE 9.8.9
Tire damage.
Courtesy of the Arlington County Police Department, VA.

Coordinator at the Metropolitan Police Institute, the Training Bureau of the Miami-Dade Police Department, suggests that a very close examination of the VIN rivets is necessary to detect alterations and possible stolen VINs.

- Pedals: Brakes, clutch, accelerator (to match with impressions on the shoes of the driver). With a heavy front-end accident, the driver's shoes, or bare feet, may take on the pattern of the pedal they had been on, and/or the shoe tread pattern may be transferred to the pedal the shoe was on, which is one way to establish the driver of the vehicle when three occupants are standing outside the car, each pointing to the other when asked who the driver was (see Fig. 9.8.10).

In this discussion about the close examination of shoe wear of those at vehicle crash scenes, the same goes for pedestrians involved in crashes. At times, when a pedestrian is struck by a vehicle, his or her quick lateral movement may result in shoes coming off, as the shoes "grip" the pavement. At times, the pedestrian's shoes may mark the pavement where he or she was standing at the time of impact.

- Safety equipment: Airbags, seat belts. Photographically document their use or nonuse (see Fig. 9.8.11).
- Paint transfers, particularly in hit-and-run crashes.
- Vehicle lamp filaments to ascertain whether the lights were on or off at the time of the crash (see Fig. 9.8.12).



FIGURE 9.8.10
Pedal marks on sandal and foot.
Courtesy of the Arlington County Police Department, VA.

Fig. 9.8.12 shows several variations likely to be encountered at vehicle crash scenes. The top left image shows a bulb with filaments for both high-beam and low-beam lighting in the same bulb. Both filaments are straight, indicating they have not been involved in a crash. The bottom left image shows some flexing or bending of the two filaments, normally an indication of the light being "on," and therefore, the filament was hot and flexible at the time of the impact. A hot filament will bend toward the impact direction.

The right image shows a broken bulb that had two filaments in it. If you look carefully, you can see broken glass melted onto the right filament, which is a sure sign this filament was incandescent at the time of the crash when the bulb broke. The left filament is exhibiting "rainbow" coloration, without heavy oxidation, indicating it was off but near a filament that was incandescent at the time of the crash. Being near an incandescent filament, the left filament was hot but not incandescent itself. Sometimes high and low beams are made with two different bulbs. Sometimes a single bulb can serve as both a high and low beam with two different filaments.



FIGURE 9.8.11
Air bags deployed.
Courtesy of the Arlington County Police Department, VA.

- Speedometer dial: Is the needle frozen in place or did it slap the dial at impact? Before newer digital dials took over the dashboard, dials had needles to indicate speed, rpm, and other aspects of the engine. Frequently, the tips of these needles were coated with fluorescent paint to make them easier to see at night. During heavy front-end crashes, the needle would sometimes slap the face of the dial, and with an ultraviolet light, the speed at impact could be seen by a faint fluorescence of the dial's surface where the needle slapped it. Newer dashboards with digital readouts make this type of evidence unlikely now. At times, the needle would also jam at its impact position. Fig. 9.8.13 shows one needle jammed at 6000 rpm. The top two images demonstrate the need for fill-flash on bright sunny days. When the damage is on the shade side of the vehicle or any aspect of the vehicle in the shade needs to be documented, fill-flash comes to the rescue.
- Detached/missing vehicle parts: Have they been located (Fig. 9.8.14)? In this case, a partial tail light found at the crash scene was eventually fracture matched to a suspect vehicle.
- Overhead view: Sometimes the best way to see which direction the force(s) came from.
- Undercarriage view: Sometimes this relates to the damage in the roadway or to objects/people that have been driven over (see Figs. 9.8.15 and 9.8.16). Fig. 9.8.16 shows an image with a crash victim's hair located under the vehicle.

Human Bodily Injury

At times, the only way to position the occupants of a vehicle within the vehicle before the crash is to match the patterns of the personal injuries suffered during the crash with the damage to the vehicles or to other aspects of the shape of the vehicle. This is because sometimes the occupants are unwilling or are unable to just tell investigators where they were inside the vehicle at the time of the vehicle crash. The driver may fear he or she will be charged with being at fault in the crash. The driver may not have a driver's license, or it may have been suspended. The driver may be intoxicated. The vehicle may have been stolen, and the driver prefers to be thought of as "just a hitchhiker." The occupants of the vehicle may be injured and unable to talk, unconscious, or dead.

In these circumstances, often the parties can be positioned inside the vehicle on the basis of their injuries. In Fig. 9.8.17, notice the patterned injury made by a seat belt on the shoulder of the left subject. This individual will have a difficult time denying he was the driver, just as a person with bruises to the chest in the shape of an oval similar to the steering wheel would. The grill of a truck struck the subject on the top right. The subject on the bottom right was the driver of a car struck on the driver's door.

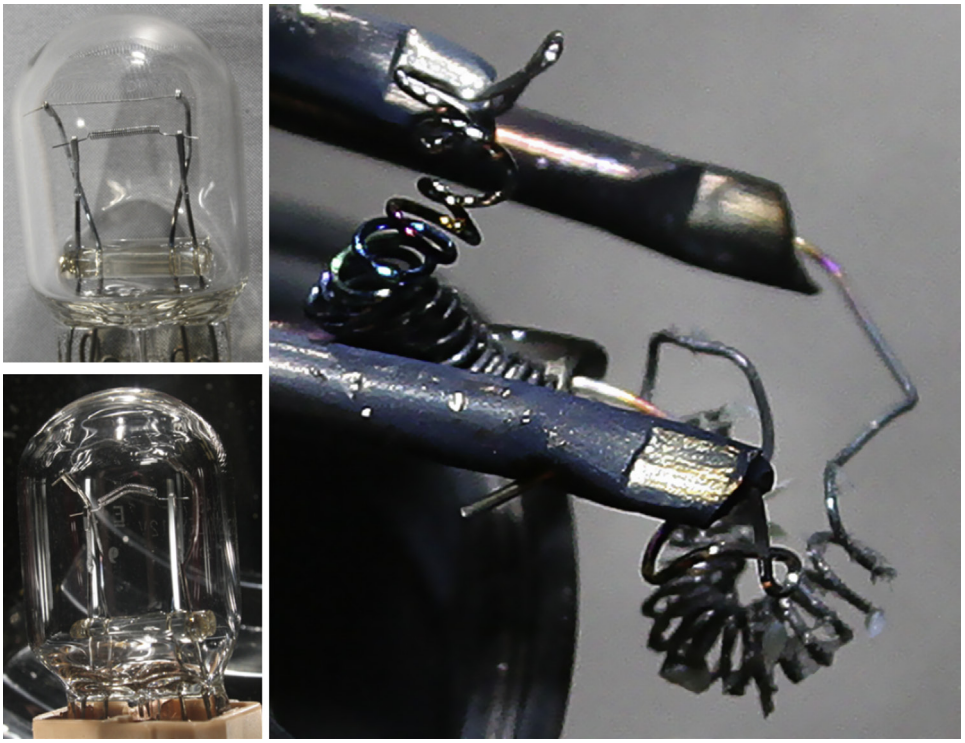


FIGURE 9.8.12
Double light bulb filaments.
Courtesy of MPO Marc Hackett, Arlington County Police Department, VA.



FIGURE 9.8.13
Speed and RPM dials.
Courtesy of the Arlington County Police Department, VA.



FIGURE 9.8.14
Tail light from crash scene fracture matched to suspect vehicle.
Courtesy of MPO Marc Hackett, Arlington County Police Department, VA.



FIGURE 9.8.15
Undercarriage damage.
Courtesy of MPO Marc Hackett, Arlington County Police Department, VA.

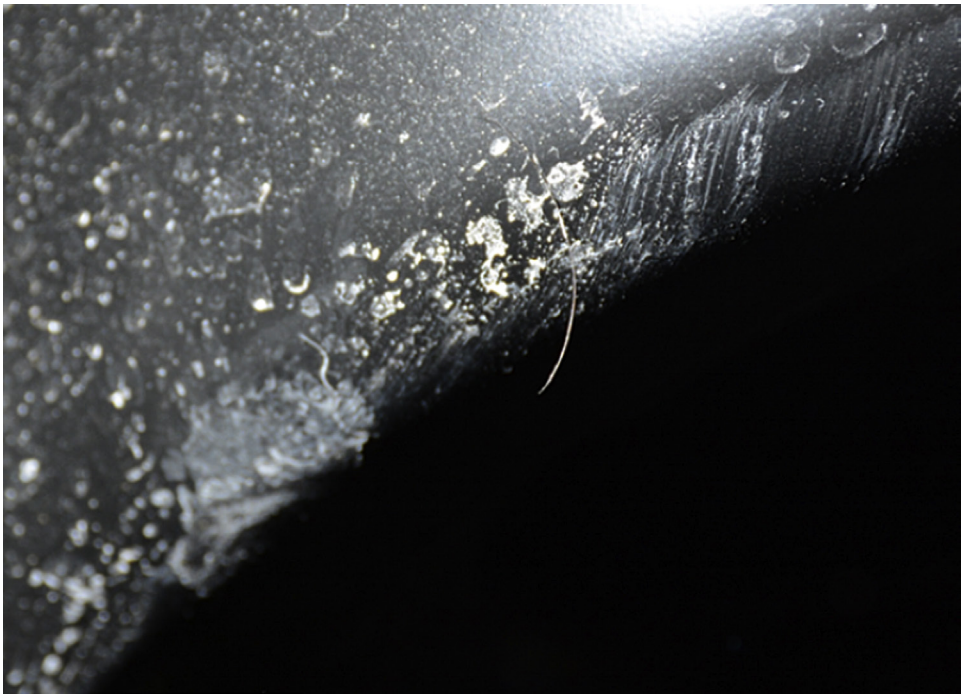


FIGURE 9.8.16
Victim's hair located under vehicle.
Courtesy of MPO Marc Hackett, Arlington County Police Department, VA.



FIGURE 9.8.17
Accident injuries.
Courtesy of the Arlington County Police Department, VA.



FIGURE 9.8.18
Windshield damage: two from the outside; three from the inside.
Courtesy of the Arlington County Police Department, VA.

Damage to the windshield and corresponding bruising/scratches to the forehead of the occupants may be the only way to determine how people were positioned within a vehicle. Pedestrians may also impact a vehicle. Fig. 9.8.18 shows two pedestrian head impacts to the windshields of the top two vehicles. The bottom image indicates the danger of not wearing seat belts and having the vehicle stop abruptly. Three subjects in the front of the vehicle left their marks on the inside of the windshield. The corresponding injuries could cause bleeding and may enable the use of DNA to match the occupants to the impact areas.

Do not forget that if an air bag deployed that the face slamming into the air bag will create a transfer of skin cells to the air bag and then DNA could be used to determine whom might have been driving at the time of the crash.

Finally, if occupants have been ejected from the vehicle during the vehicle crash, it may be possible to closely inspect the windows or doors through which it is suspected they exited the vehicle and find hair, tissue, or clothing fibers there, confirming that was their exit route. Detailed photographic documentation of all these types of evidence may prevent the need for difficult and lengthy investigations later.

Because many jurisdictions use different personnel to process vehicle crash scenes and crime scenes, as if the two investigations are always very distinct from each other, Frank Carson suggests that there be some cross-training of the two units because there will inevitably be times they must do double duty and assist each other. Preparation is the key to success.

Nighttime Vehicle Crash Photography

The painting with light technique may serve to properly expose large, dimly lit vehicle crash and crime scenes. Two other techniques exist that you may wish to keep on your Bat-Belt to use at your convenience. Although the painting with light technique will always ensure the colors of the scene are properly documented (ensure your digital White Balance has been set for flash), if no bright ambient lights are too close to your vehicle crash scene or crime scene, these other techniques may be considered. When bright ambient lights are present, the resulting photographs may

contain unwanted color tints. In large, dimly lit scenes, sometimes the colors of the evidence within the scenes are not important. Just including them in a photograph is. Some digital cameras allow you to preselect a black-and-white image capture mode. Of course, if distracting color tints are included in your images, you may also elect to post-process these digital images and save a copy of the original as a grayscale image. Or, if distracting tints occur in an image, post-processing the image to remove tints is certainly also possible.

Time Exposures

When film cameras were still king and seeing an instant display of your photographic talent was not possible, it was sometimes necessary to do time exposures at large, dimly lit outdoors scenes to ensure a usable exposure was captured. A precondition to obtaining a well-exposed image was the absence of bright ambient lights too close to the scene of interest. If the predominant light was just from the stars and the moon, this technique frequently produced satisfactory results.

The film of choice was 400 ISO color film. The aperture would be set to f/8, and the camera would be hyperfocal focused. This meant that the exact focus was set for 30′, and this setting resulted in a depth of field range of 15′ to infinity. The shutter speed necessary for a good exposure was pure guesswork, and aperture priority exposure modes were not available yet. However, great results could be anticipated from locking the shutter open for 2, 4, and 8 min on successive shots. One of those exposures would frequently be usable. Time exposures have already been covered in this text.

Time exposures with a digital camera would be easier to achieve because after the first image was captured, a pretty accurate "guesstimate" of the second exposure could be obtained from seeing the exposure of the first image. Even easier, however, would be to use the aperture priority exposure mode.

Aperture Priority Overalls

With digital cameras becoming more pervasive in crime scene and vehicle crash scene photography, the entire process is simplified somewhat. Again, 400 ISO is recommended, as is f/8 and hyperfocal focusing. Now, however, the camera is set to aperture priority exposure mode. Theoretically, when sufficient light comes into the camera through the lens, the shutter will close, completing the image capture. Again, caution should be used if bright ambient lights are in the immediate area. The camera's light meter may preferentially meter the light coming from these bright light sources, ensuring they are properly exposed, but the rest of the scene may be underexposed.

To minimize this risk, you can use a spot meter, if the camera has one. Then, the shutter will close only when the area the spot meter is set on has received sufficient light. This provides more control over the exposure where it is needed: in the dimly lit areas. If the initial exposure is not properly exposed, the exposure compensation dial can be set to +1 or −1 as needed.

Fig. 9.8.19 shows a crash scene on a major highway. The top image shows the dimly lit scene photographed with a single flash. The bottom image is an aperture priority exposure. This image also caught a plane streaking across the sky with its long exposure.

Fig. 9.8.20 shows an image of the Home Depot Washington, DC area where snipers, John Allen Muhammad and John Lee Malvo, shot and killed Linda Franklin in Falls Church, Virginia. Linda Franklin was one of ten killed and four wounded by the snipers in 2002. The aperture priority exposure mode was used in this image the night of the shooting.

A combination of the above procedures in an attempt to get a photo at night of a large area can be utilized. Such as using an LED flashlight or spotlight during aperture priority or time exposures to assist with illumination of areas that maybe shadowed due to ambient light. (Ensure that the flashlight or spotlight is used only after the meter reading is completed and the shutter is open.) Or, one can also consider the use of a flash unit being fired off in the time exposure or aperture priority mode to give light to your scene where you may need it.

Another technique to possibly use is high dynamic range (HDR) photography. This could be used during time exposure to "bracket" your exposure using the shutter speed only. Once you have taken three to five "bracketed" photographs you could use software to take those images and produce an evenly balanced photograph. HDR photography is explained in the Appendix.



FIGURE 9.8.19
Aperture priority overall.
Courtesy of Cpl. Lisa Haring, Arlington County Police Department, VA.



FIGURE 9.8.20
Aperture priority overall.
Courtesy of Photographic Specialist Keith Dobuler, Fairfax County Police Department, VA.

SUMMARY

Working at a vehicle crash scene is potentially very dangerous to all concerned. Before photographs can be safely taken at major vehicle crash scenes, several priorities have to be dealt with. Law enforcement officers have many responsibilities: to protect the vehicle crash scene, manage the traffic flow, and document the scene as part of their responsibility to work the crash and complete an accident report. The same aspects of the scene need to be documented whether or not the photographer has been trained in accident reconstruction. This chapter presented an overview of the concerns of the photographer at a major vehicle crash scene.

DISCUSSION QUESTIONS

1. Before a major vehicle crash scene can be photographed, safety issues have to be addressed. What are they?
2. The immediate vehicle crash scene cannot be isolated from its surroundings. How does this apply to the photographic documentation of a major vehicle crash?
3. How should the vehicles involved in a major vehicle crash be photographed?
4. How can photography document the wounds and injuries to the occupants of the vehicles in major vehicle crash?
5. Large vehicle crash scenes can be lit by the painting with light technique during the nighttime. Discuss two other photography techniques sometimes used for large, dimly lit vehicle crash scenes.

Further Reading

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CHAPTER 10

Digital Imaging Technologies

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Key Terms
Airbrushing
Artifacts
Bayer Pattern
Bit
Byte
Cluster of Dots (or Device Dot Cluster)
Digital Evidence
Digital Image
Dynamic Range
Film Recorder
Interpolated
JPG
Lossless Compression
Lossy Compression
Metadata
Monitor Resolution
Noise
Pixels
Process
Raw Format
TIF

Learning Objectives

On completion of this chapter, you will be able to

1. Explain the components of a digital image;
2. Explain what image quality means as it relates to a digital image;
3. Explain the difference between dots per inch (dpi) and pixels per inch (ppi);
4. Explain the differences between image resolution, monitor resolution, and printer resolution;
5. Explain how ppi are converted to dpi;
6. Identify and explain the differences between the image file formats used in digital cameras;
7. Explain the difference between lossy compression and lossless compression;
8. Explain the best practices for photographing evidence to maximize image quality.

THE CLICHÉ

"A picture is worth a thousand words…" "[p]hotos don't lie…" "I'll believe it when I see it…" These are just a few of the clichés that have been around for as long as any of us can remember. But in law enforcement, these clichés paint a very different picture—they can be very

Crime Scene Photography. http://dx.doi.org/10.1016/B978-0-12-802764-6.00010-6
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persuasive and invoke an emotional or cognitive response. Special procedures must be followed when photographing a crime scene so that the pictures will help tell the whole story. (The crime scene photographer who does not get called into court to explain his or her photographs is a very successful photographer!) Special procedures must be followed after the pictures are taken so that the pictures can be validated as a "true and correct copy" that "accurately and reliably depicts" what it purports to depict. In addition, we have to "visualize" (aka "analyze") the content of the picture and form a conclusion (a 1000 or more words) about the image.

The history of photography dates back to the camera obscura—a technology in which external light passed through a hole in a box where the light would strike a surface and inverting the image but preserving color and perspective. The "image" was then projected onto paper where the image was traced to produce a "highly accurate" image.

But using yet another cliché, "we have come a long way, baby!" In the early 1800s, the **Process** of daguerreotype photography was discovered as well as the paper coated with silver chloride. The first color photography—combined three photographs taken through red, green, and blue color filters and then superimposed the photos to make a single color image. The early 1900s saw the introduction of Kodachrome film, and as the old saying goes, "[t]he rest is history."

By now, you are most likely asking yourself, "Where the heck are we going with this?" The point is that throughout the history of photography, images have been created from light and the images have been written (as well as traced) onto a surface to create a visual representation. Using digital photography, pictures are no longer being written to a surface such as paper or film. Instead, light is converted to an electrical charge that is captured on a semiconductor and then transferred to a storage medium.

For all of you history buffs and/or trivia fans, 2016, will celebrate the 30th anniversary of Kodak's first megapixel (MP) imaging sensor. In 1994, the Kodak DCS420 digital camera, which was a 1.83-MP camera, sold for a sum in excess of $8000 (US). In 2012, a Nokia 808 PureView with a 41-MP camera (a Carl Zeiss sensor) sold for less than $800 (US). Today smartphones are available with digital cameras that range from 3 to 41 MP, and some 13- and 16-MP smartphones take as good if not better images that some 20-MP "commercial grade" digital cameras (aka "point-and-shoot" cameras).

Over the years, data from digital cameras were stored on PCMCIA cards (so named because of the Personal Computer Memory Card International Association standards). The use of these standards have also led to the development of many other types of storage media, such as Compact Flash cards, Secure Digital (SD) cards, MiniSD cards, MicroSD cards, MultiMedia Cards, Memory Sticks, Smart Media cards, and Extreme Digital cards.

For more than a 100 years, the courts have widely acknowledged that photography is the most accurate way of documenting evidence[1], but with data stored digitally on electronic media, there is no "picture" that is created. This leads to the perceptions that digital imaging is not as reliable as film, that **Digital Images** can be manipulated easily, and that digital images are misleading, subject to issues visualizing and interpreting the electronic data, so on and so forth.

Furthermore, television programs like "Brain Games" on the National Geographic Channel, or other programs that have featured optical illusions that demonstrate issues effecting visualization as well as believability or reliability. So whether it was a film image or a digital image, there are still issues regarding "visualization" of the picture and "interpretation" of the image … what does it accurately and reliably portray?

BIAS AND UNCERTAINTY

The issue of accuracy has been heightened to an all-new level in the courts. This awareness—and desire—for stating accuracy and probability is driven in large part by the use of DNA testing (also known as DNA profiling). While 99.9% of human DNA sequences are the same in every person in the world.[2]

Most forensic labs today focus on 13 STR (short tandem repeat) core genetic DNA sequence characteristics (Loci) to determine the virtual certainty that two DNA samples came from the same individual (or an identical twin).[3]

In digital photography, we do not have just 13 characteristics to point to for a virtual certainty. We must rely on a response based upon a condition or stimulus. Typically, anyone who relies on photography within the criminal justice

[1]Singh, Kumar, Nanra, and Kumar. "Why Is The Crime Scene Photographed? There Is Not A Single Answer!" *Internet Scientific Publications* (http://isub.com/IJFS/5/1/13846).
[2]Tam, Jessica. "Forensic Evidence: The Reliability of DNA Testing" (http://www.legalmatch.com/law-library/article/forensic-evidence-the-reliability-of-dna-testing.html).
[3]The Biology Project, University of Arizona. "Blackett Family DNA Activity 2. What are the 13 core CODIS loci?" (http://www.biology.arizona.edu/human_bio/activities/blackett2/str_codis.html, October 27, 2000).

community is required to make decisions based upon their interpretation of data that is present in the visual representation of that data. "When judgments are made under uncertainty, two general types of errors are possible—false positive and false negatives. A decision-maker cannot simultaneously minimize both errors because decreasing the likelihood of one error necessarily increases the likelihood of the other."[4]

This chapter and the proceeding chapter are dedicated to promoting an understanding of the fundamentals of digital imaging technologies, and how to ensure that the digital photographic data are understood to minimize bias and uncertainty, and to ensure that digital images are handled (captured, stored, managed, and processed) in a manner that supports testimony under oath "that this picture is a true, accurate, and reliable depiction" of what it portrays. We will also discuss what tools, methods and/or techniques can be used to alter digital image data and invalidate the methods used to defeat the ability to determine whether or not the image is a true, accurate, and reliable image.

A Brief History of Photography as Evidence

Traditional photography and its associated image processes have been used in legal matters since 1839 (Scott, 1969, vol. 1, p. 2). In addition, the earliest documentation of prison inmates dates back to 1843 in Belgium and 1851 in Denmark. By the 1870s, professional photographers were employed to take photographs of criminals.

Because of this long-standing history and precedence, photographs have been accepted in the courtroom as true and accurate representations. Until some of the more recent well-known cases were tried, many defense attorneys would not even consider challenging the use of conventional film because they believed that it was difficult to commit fraud using conventional, silver halide-based film. "Fraud by conventional photography was difficult, expensive, and easily detectable … contemporary technology has made manipulation of digital images easy, inexpensive, and seamless…" (McCarvel, 1995). Consequently, many people in law enforcement have had the mistaken idea that traditional film processing provides a higher level of image integrity and provides a more secure (both physical and long-term) method for storing images. The truth of the matter is that this absolutely is not true.

Since the invention of photography as a medium, photographers have strived to distort reality instead of accurately reflecting reliable depictions. Photographs have been retouched by use of a number of image capture (camera), development, and printing techniques since the 1800s. For example, **Airbrushing** was developed in 1879 by Abner Peeler, and a patent for this technique was issued to Charles Burdick in 1893.

A simple Google search on "photographic manipulation" will produce hundreds if not thousands of examples of photographs that were altered or manipulated long before Adobe Photoshop. In fact, one of the most famous pictures of Abraham Lincoln is actually a manipulated image: the head of Abraham Lincoln was placed on top of John Calhoun's body in 1860. (Calhoun had died a decade earlier in 1850.)

In its early implementation in photography, airbrushing involved a small, precise tool for spraying paint. In addition to blending colors, such as adding shadows, this technique provided the ability to hide signs that an image had been manipulated. As a result, images could be cut and pasted from one photograph to another, and airbrushing and over/under exposing of negatives completed the manipulation.

Until the 1920s, airbrushing techniques were used *primarily* for photographic (color) retouching. As new photographic tools and technologies were invented, new airbrushing techniques were used to create modified pictures, such as the propaganda posters created and used by the US Army during World Wars I and II. As early as 1929, shortly after the first commercially available cameras were introduced, Joseph Stalin had his enemies airbrushed out of photographs, as shown in Fig. 10.1.

There have also been numerous techniques other than just airbrushing practiced over the years to enhance and even manipulate photographs. In 1969, John Cohen exhibited more than 40 special effect techniques that he devised on the basis of photographing projected images years before computer manipulation ever existed. Airbrushing and other image manipulation techniques have been used by the print media for years. Surely, you are familiar with the "true and accurate images" that have appeared in well-known publications such as *National Enquirer*, *Celebrity News*, *Gossip*, and other magazines.

There are a number of basic photographic processes that can also be used "creatively" to manipulate an image. For example, a photograph can be manipulated by changing exposure, camera angle, choosing the wrong (improper) lens, etc. For example, you could misrepresent and mislead someone viewing a picture of a small hole in the ground by using a wide-angle lens to make the hole appear to be a large abyss.

[4]Green, David M. and Swets, John A. Signal Detection Theory and Psychophysics, 1996.

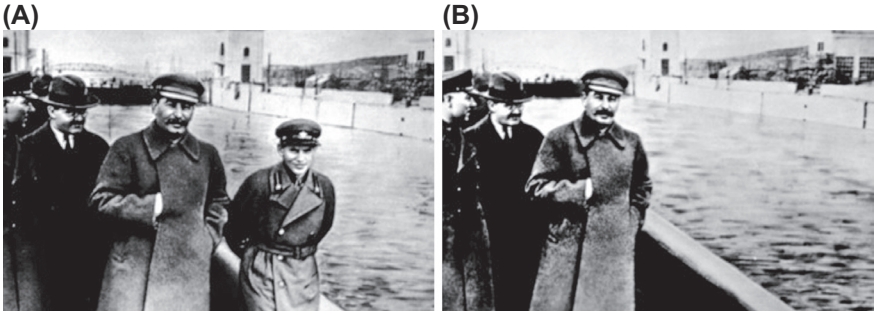


FIGURE 10.1
Stalin frequently had his enemies airbrushed out of pictures. For a period of time, Nikolai Yezhov, chief of the Soviet secret police, was close to Stalin. In the first picture, he is seen with Stalin (A). But he does not appear in the manipulated photo (B).
Pictures taken from The Commissar Vanishes.

The question, then, is why do attorneys and law enforcement agencies put so much faith in traditional film photography when there has been such a long history of image manipulation?

The rapid growth of digital technologies for the past three decades has made manipulation of traditional silver halide film images even easier. The proliferation of film and flatbed scanners has made it extremely easy for even novice users to digitize a photograph. And with even the simplest image editing tools, they can perform a myriad of tasks, including merging images and changing the contents of those images, changing colors, restoring old/damaged photographs, and the like.

In the 1980s and 1990s, slides for presentations were created using computers and a number of image processing tools available at that time, such as Adobe Photoshop, Paintshop Pro, PhotoImpact, and so forth. Using a **Film Recorder**, digital images were projected directly onto film from the computer rather than printing a hard-copy image that had to be photographed and then processed. The result was a film-based, high-quality presentation … or high-quality "pictures" on film that was not based on a real time, place, or event. So the myth that film is more secure than digital is just that: It is a myth!

Film recorders like the one shown in Fig. 10.2 can record up to 16,000 lines of resolution, which represents an addressable resolution of 16,384 picture elements (aka pixels) by 13,448 pixels, which is approximately 220.3 million pixels (aka "megapixels" or MP).

However, high-quality liquid crystal display (LCD) projectors have replaced the use of slide projectors because of their increasing image quality (both lumens and resolution). It is no longer necessary to create images that must be projected onto film with film recorders, then have the film developed and mounted into frames, and finally inserted into slide trays. These images are now created, managed, and displayed directly from the computer, giving higher-quality images much faster with significantly less hassle. (I am confident that John Cohen would have been able to produce more than just 40 special effect techniques if he would have had today's technologies in 1969!)

Although these new technologies have helped improve speed and image quality, the acceptance and use of these technologies have created numerous problems in law enforcement. Not only are we facing questions about the integrity of our digital images, we are facing challenges about our ability to identify if, when, where, and by whom computer enhancements were made. And, in some cases, even our personal integrity is being questioned.

The good news for law enforcement is that unlike traditional film cameras, digital cameras provide the ability to identify whether an original image has been altered. For example, all digital cameras manufactured within the past decade capture information about the image **Pixels** (also known as picture elements) together with information such as date and time when the image was taken and camera settings such as aperture setting, shutter speed, ISO, flash settings, exposure compensation, lens used, focus distance, and so forth.

These data elements (also known as camera exchangeable image file format **EXIF data**) are then stored as part of the image file in a collection of data fields called the file header (also known as **Metadata**). This format has become the standard for storing camera information, thus providing interoperability between digital cameras and image processing programs.

EXIF data has also proven to be very useful because photographers with digital cameras do not have to worry about recording the settings they used in a photo log. When a photograph is taken, the image data together with the

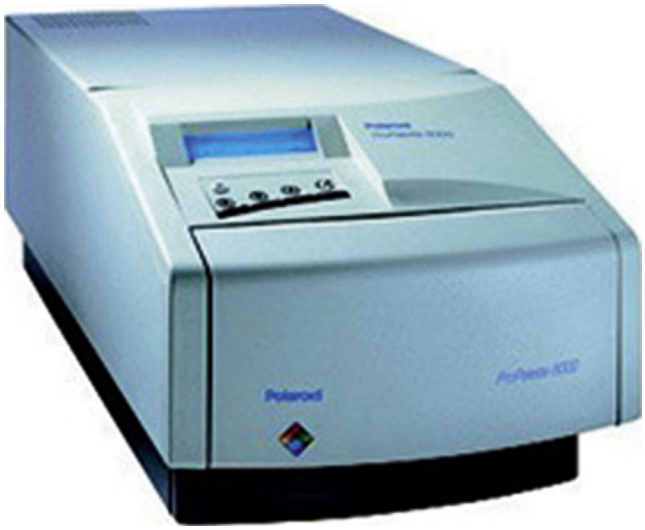


FIGURE 10.2
High-resolution liquid crystal display projectors coupled with applications like Microsoft PowerPoint have replaced the need to create slides for presentations. However, film recorders like the Polaroid Propalette 8000 digital film recorder are still available, which means you could still make your own negatives from digital images if you had the desire to do so.
Picture taken from actual eBay listing.

information about the device and the image capture, including but not limited to the camera make, model, and serial number, and all the camera settings used, etc., are stored with the image. Later, photographers can analyze these data and determine which camera settings provided the best results, thereby learning from their photographic experiences, which is something that simply cannot be done easily with a film camera.

In years past, the FBI as well as many larger law enforcement agencies required that two photographers be present at each crime scene: One photographer operated the camera, while the second photographer manually recorded the camera settings on a photo log. As can be imagined, this was a very time-consuming and labor-intensive process. Yet it did nothing to preserve and protect the integrity of the image captured on film. Plus, no matter how professional or attentive to detail a person may be, people make mistakes.

RULE OF THUMB 10.1

Most image editing and viewing programs provide the ability to display EXIF camera data when processing the image. There are, however, still some image editing programs that overwrite or simply ignore the existence of EXIF data when the image file is resaved after editing. Hence, it is imperative to always maintain and preserve the integrity of original digital images.

Be sure to maintain the EXIF data for all forensic digital image files not only for reference of detailed camera settings, but also for purposes of demonstrating image authentication and integrity.

With the proper digital image processing safeguards in place, there should not be questions about whether or not the original image was altered, retouched, and/or rerecorded. The reality is that digital imaging provides a faster, more secure imaging solution than film was ever capable of providing, and digital imaging provides the best line of defense for proving image integrity. But do not get too comfy just yet! There are tools and techniques that can limit—or invalidate—the ability to authenticate digital images.

The New Digital Arsenal for Law Enforcement

The digital revolution has forever changed the way we think about "information" and how that information is stored, accessed, maintained, and communicated. While oral testimony is handled in the courts in much the same manner as it has been over the years, the courts must now deal with a variety of **Digital Evidence**, such as images downloaded from the internet, computer animations and simulations, computer-generated images, digital photographs, and manipulated images. Some courts have maintained a skeptical eye on digital technologies, while some defense attorneys and others have urged the creation of new standards as well as how to address objections to digital evidence authentication.

Note: "Digital" evidence (in electronic data form) is rarely, if ever, in a format that can be read easily by most people. As a result, another step is required for admitting digital evidence into court: it has to be printed or viewed in court. Federal Rules of Evidence, Rule 1001 (3) states: "if data are stored in a computer, any printout or other output readable by sight, shown to reflect the data accurately, is an original."

Digital video recorders are being used for surveillance, crime scene analysis, and investigation, as well as in patrol cars and more. Digital technologies have also provided a new arsenal of weapons for the courtroom, enabling law enforcement personnel to clearly articulate and illustrate their analysis and investigation through the use of digital photographs (PowerPoint presentations) and computer simulations.

Digital imaging has become the weapon of choice for arson investigations, crime scene investigation, fingerprint identification, domestic violence cases, and so forth. Digital technologies have enhanced the way we do crime scene reconstruction, calculate blood spatter trajectories, create photo lineups, create wanted and missing persons fliers, and manage evidence and property. Medical examiners are using digital imaging technologies during autopsies; nurses are using digital technologies during sexual assault investigations.

Just a few years ago, it would take days or even weeks for domestic violence or sexual assault cases to be heard, and the photographs that were used were often blurry or they failed to show the extent of the actual injuries.

With digital technologies, images of injuries such as black eyes, bruised cheeks, handprints around the neck, scratches, and abrasions can be sent by means of computer from the detective to the prosecutors and judges before arraignment of the suspect. In this case, the judge can decide whether or not to grant bail or issue a restraining order to safeguard the victim.

Although these digital technologies enable criminals to be prosecuted faster and, in many cases, save lives, new challenges are also being made in the courtroom. Allegations and insinuations that challenge the integrity, quality, and authenticity of digital images have been made against law enforcement. Defense attorneys challenge the use of these technologies saying that digital images can be altered easily or that the technology is not scientific or not reliable. Unfortunately, the burden of proof rests not on the defense attorney who made the allegations, but on the prosecutor who must defend the use of the technology and demonstrate that the technology is not only sound, but that it is reliable, and, most importantly, that it has been used properly (see Fig. 10.3).



FIGURE 10.3
Digital technologies assist in catching and convicting the bad guys.

While there has been a significant push to get law enforcement people to use digital imaging technologies properly, many people (both in and out of law enforcement) equate digital image quality exclusively with the digital camera and fail to understand that output—displayed on a monitor or printed on a page—plays the most crucial role in how we perceive the use of digital imaging technologies. The result of this confusion has led many law enforcement agencies to make choices that ultimately have had a negative impact on their ability to optimize the use of their digital images.

For example, one of the most frustrating challenges that law enforcement agencies face internally is that many supervisors do not appreciate or understand the difference between a **Lossy Compression** (JPG) capture format and a **Lossless Compression** (RAW or **TIF**) capture format.

Cameras that use lossy compression, such as the compression inherent in a **JPG** format, discard actual picture information to create smaller file sizes. When these images are subsequently decompressed, displayed, and enhanced, **Artifacts** are added into the image. This opens a huge door for attorneys to challenge both the quality of the image and the analysis of the image, as shown in Fig. 10.4.

When presenting these images in court, the forensic expert must be knowledgeable about these issues and must be able to articulate the effects of a lossy compression scheme compared with a lossless compression on the image. Certainly, in some instances, such as traffic accidents and general crime scene photographs, the effects of a lossy compression will not have a significant effect on the content of the image. Any image that requires analysis, however, should be captured by use of a lossless compression scheme.

Arresting New Developments

During the past three decades, we have witnessed a phenomenal surge in the development, use, and acceptance of digital technologies within national security, antiterrorism efforts, law enforcement, and criminal investigation. Not only has the use of digital cameras become widespread, but the use of digital technologies in the courtroom has flourished as well.

In addition to increasing productivity, digital technologies have afforded law enforcement agencies the ability to reduce and even eliminate film, processing, and printing costs while minimizing development/processing time. More importantly, digital technologies provide immediate access to vital information. There are a number of law enforcement agencies throughout the country that share their images with State's Attorney's offices, District Attorney's offices, etc. electronically, without the need to print contact sheets or countless hundreds of photographs that must be shared as part of the discovery process, or create multiple copies of CD or DVDs with digital evidence. Not only is there an immense time savings, but there is an enormous savings in paper, ink, disks, etc.

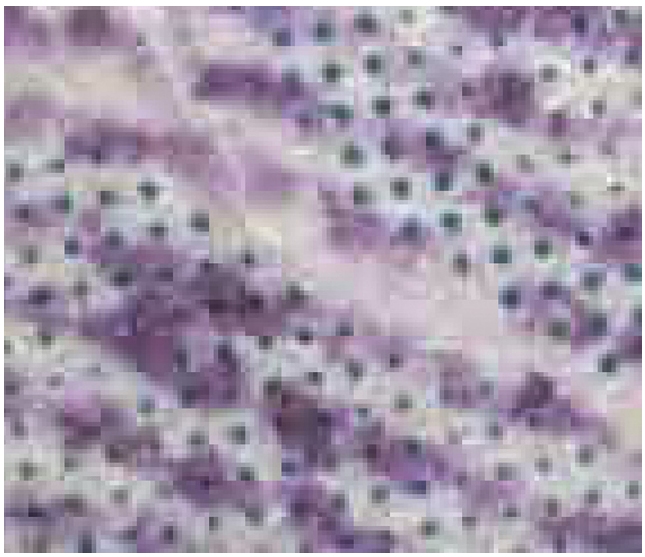


FIGURE 10.4
Ridges? "We don't need no stinkin' ridges!" Compression may not only destroy crucial second- and third-level ridge detail, but it can also cause "blocking" artifacts that merge ridge detail and background obstructions, thus making it difficult not only to identify ridge flow and ridge events, but also to eliminate background **Noise** that interferes with the identification process.

Some trade-offs also exist. A growing mandate exists for better (higher-resolution) images, standardized image processing techniques, better image management and storage processes, and training.

Although these mandates have helped create leading-edge hardware and software products, they have also forced us to adapt technologies to meet specific investigative requirements and provide innovative and effective information technology solutions for the courts and law enforcement agencies worldwide.

The greater acceptance of digital technologies both in and out of the law enforcement community has been primarily the result of new, affordable high-resolution digital cameras. These cameras have changed drastically the way we do image capture, analysis, and enhancement, making the images more reliable and more dependable.

Since the digital imaging revolution began in the early 1990s with the release of software applications such as Dr. Halo and Adobe Photoshop, imaging technologies have changed, and image processing capabilities have improved significantly. Digital cameras have a greater **Dynamic Range** and include a vast array of new capabilities; new digital video recorders have improved the way we analyze surveillance videos or document and analyze crime scenes.

Capturing the image is only one piece of the puzzle. To complete the analysis, we must often process the image for better visualization. Adobe Photoshop is one of the oldest, most widely used and most widely accepted image-editing applications available. Photoshop has been used by the law enforcement community for more than 15 years to process and prepare latent prints for submission to Automated Fingerprint Identification Systems, perform crime scene analysis, create mug shot lineups, create facial composite drawings, perform facial reconstruction of unidentified victims, prepare court exhibits, and much more.

As is the case with all technologies, baseline standards, recommended techniques, and generally accepted guidelines exist. Although specific image editing procedures or techniques are not mandated, the question that must be answered is: Would an individual with comparable training, skill, expertise, and experience be able to create a reasonable likeness of the same image?

Our experience with conventional photography has taught us that not everyone has the same skill when it comes to photographing a difficult object. The angle of the light, the density and intensity of light, the filter(s) being used, and so forth will drastically affect image quality. It is only through experience that we develop the ability to capture those types of images.

Similarly, it is only through training and experience that we develop the ability to **Process** (enhance) digital images as well.

Even the printer (inkjet, laser, or dye sublimation) that we use can affect the quality of the image because of the different types of inks (dye versus pigment) and the different types of paper (plain, matte, and glossy).

Some inkjet printer manufacturers use "multisize dot technology" together with multi- or single-pass technology, where the color value for each output pixel is created by multiple passes of the print head that sprays varying size ink droplets typically ranging from 1.0 pL droplets to 20.0 pL droplets directly onto the paper to create an image.

In addition, most inkjet printers use a number of ink colors compared with the old days when cyan, magenta, yellow, and black were the rule. For example, inkjet prints can have any combination of red, blue, green, cyan, photo cyan, magenta, photo magenta, yellow, photo yellow, regular black, matte black, light black, and light-light black. (Some manufacturers refer to light black as gray, and light-light black as light gray.)

Inkjet printers provide a range of options regarding the number of nozzles per print cartridge, ranging from 180 nozzles per print cartridge to 2560 nozzles per print cartridge. Although we are still limited by the printer's rated **dpi**, image quality can be improved by choosing a printer with more ink colors, smaller picoliter droplets, and a higher nozzle count (per print cartridge).

Many people are not aware that inkjet printers automatically adjust the volume of ink that is sprayed onto the paper based on the type of paper that is used regardless of the printer's specifications. Moreover, many people do not realize that they must also adjust the printer settings to get the maximum image quality that is available with the printers.

As shown in Fig. 10.5, inkjet printers typically use a "draft" output resolution of approximately 720 dpi when printing on plain paper because the ink bleeds (is absorbed) into the surface of the paper. When glossy photo paper is used, the ink actually beads up on the surface of the paper and retains its round (dot) shape and provides a clearer image. In addition, more ink droplets can be sprayed closer together, thus providing significantly higher dpi.



FIGURE 10.5
Ink droplet on plain paper versus ink droplet on glossy paper. Ink droplet on photo glossy paper keeps its shape, while the ink droplet becomes irregular in its shape as it is absorbed into plain paper.

Laser printers, on the other hand, use a highly focused beam of light to place dot arrays onto the photoreceptor drum, which in turn transfers the image to the paper. The image itself is actually created with static electricity, dry ink (toner), and heat to bond (melt) the toner onto the paper. Unlike inkjet printers with varying ink droplet sizes, there is only one size of toner powder (particles), and the laser has only a single, unvarying diameter. Moreover, most laser printers are limited to only four colors of toner: cyan, magenta, yellow, and black.

Dye-sublimation printers (also referred to as dye-sub printers) use a roll of film that resembles sheets of red-, blue-, and yellow-colored cellophane joined together end to end. Embedded in the donor film are dyes that correspond to the colors used in printing: cyan, magenta, and yellow. Most dye-sub printers use equal parts of cyan, magenta, and yellow to create black, thus delivering all four elements of the CMYK color mode. In contrast, some dye-sub printers actually include a black-colored segment to complete the CMYK elements of color. Similar to a laser printer, the print head on a dye-sub printer contains a heating element. However, the heating elements in a dye-sub printer provide a wide range of temperatures to bond the appropriate amount of each color of dye onto the surface of the paper. Typically, dye-sub printers make a complete pass over the paper for each of the colors contained on the ribbon, thus little by little building up the image on the page.

Because of these different printing techniques, the same image printed from the same computer can appear different simply because of different output devices, as shown in Fig. 10.6.

The goal throughout the entire process is to produce the most reliable representation possible that clearly and accurately represents that which it is purported to represent.

Digital Image or Digital Evidence? The Debate Continues

Digital technologies touch almost every single facet of our lives today. More and more people are using computers, watching digital television, wearing digital watches, using digital cell phones, and so forth. The terms and words associated with these technologies are infiltrating our day-to-day language. The use (or should I say abuse) of the word "digital" to describe these technologies has created a great deal of confusion.

For purposes of discussion in this chapter, we will use the term "digital image" to refer to the process of creating an electronic image using either a digital camera or scanner from a physical object such as a document, photograph, negative or other three-dimensional object.

Please be aware that a distinction can be made between a **digital image** and **digital evidence**.

Digital images can come from many sources:

- Digital cameras
- Scanners (flatbed scanners and film scanners)
- Video cameras

As stated earlier, a digital image is typically considered to be a representation of a physical object. A digital image can also be "created" and thus not represent an actual object. From a purely legal argument, the physical object is the actual evidence; the photograph is merely documenting its existence, such as recording the existence of a fingerprint found on a piece of evidence for historical purposes, or recording an object that may change over time, such as a latent print on paper developed using a chemical process (ninhydrin) in which the actual fingerprint will fade over time. In the latter case, the line between digital image and digital evidence becomes extremely thin.

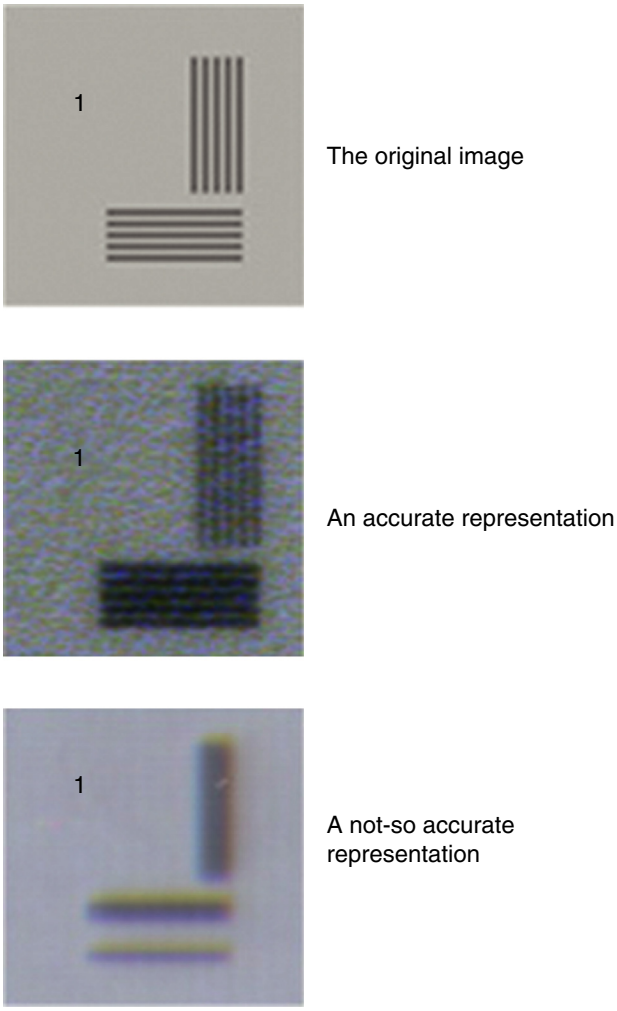


FIGURE 10.6
The ultimate goal is a reliable and accurate representation of the facts.

Note: In the case of a "created" digital image, the image itself typically is considered to be evidence, which is often the situation in child pornography cases, etc. The existence (including but not limited to the origin, method of creation, method of manipulation, etc.) gives rise to the actual cause of action. In addition, the processes for analyzing these types of digital images are different than the processes used for crime scene photography and are not discussed in this book.

To make the distinction between evidence and documentation a little clearer, think of documentation as a recording of a location or event and evidence as a physical item. For instance, a digital image could be used to document the existence of a fingerprint in blood found on a painted cement wall at the crime scene; the painted cement wall with the blood is the actual evidence.

The American Society of Crime Laboratory Directors, Laboratory Accreditation Board (ASCLD/LAB) states that when evidence, such as latent prints and impressions, can only be recorded or collected by photography and the image itself is not recoverable, the photograph or negative of the image must be treated as physical evidence. In the previous case, the painted cement wall with the blood is the actual evidence. But if the wall cannot be "collected" or is damaged during the collection process and the digital photograph of the fingerprints in the blood on the wall at the crime scene is all that remains, then the digital image must be handled with the same care as physical evidence.

The Scientific Working Group on Imaging Technology (SWGIT) also defines two categories of digital images that are commonly used in the criminal justice system throughout the United States. In Section 11, Best Practices for Documenting Image Enhancement, SWGIT defines these groups as follows:

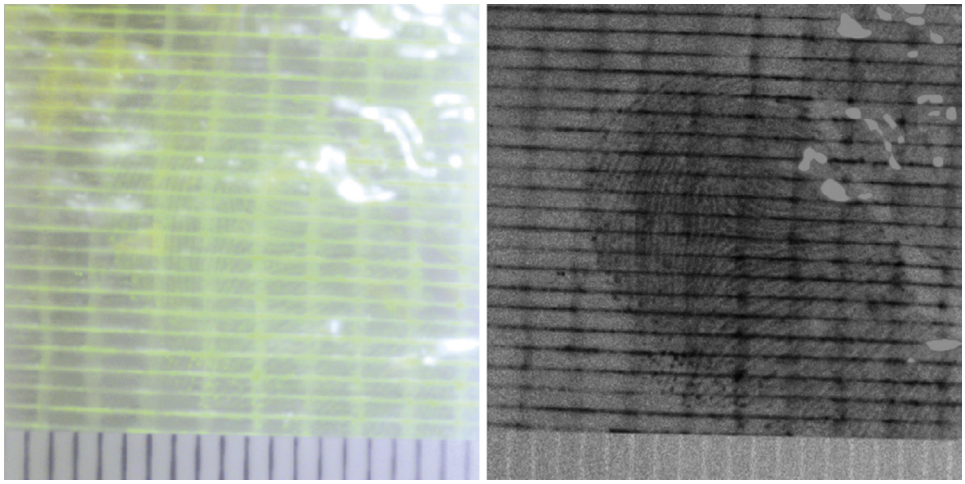


FIGURE 10.7
Images are evidence: Properly tracking the techniques used during the enhancement process and explaining which tools were used can make all the difference in the courtroom, especially when the original image appears to be unidentifiable and the processed image can be identified easily.

Category 1 (Documentation Images Used to Record a Time, Place, or Event)

- General crime scene or investigative images, including images of the actual physical evidence collected at the crime scene
- Surveillance images
- Autopsy images
- Documentation of items of evidence in a laboratory
- Arrest photographs, such as mug shots

Category 2 (Evidentiary Images Used for Scientific Analysis and Comparison)

- Latent prints (including latent fingerprints, palm prints, etc.)
- Bloodstain pattern images
- Questioned documents
- Tool mark images
- Gunshot residue images
- Impression evidence (such as footwear and tire tread) images
- Other images to be subject to analysis

(For more information, refer to SWGIT Guidelines for the Forensic Imaging Practitioner at www.swgit.org.)

The manner in which Category 1 images are captured, stored, and processed is different than the way Category 2 images are captured, stored, and processed. For example, the camera JPG format used for Category 1 images is not acceptable for Category 2 images, which should be captured using a RAW file format. The way that image processing is documented is also different. (This will be discussed in more detail in chapter "Digital Image Processing of Evidentiary Photography.")

One word of caution: In some instances, a Category 1 image can ultimately be used as a Category 2 image that must be used for analysis. The analysis, comparison, and evaluation of such a digital image captured as a Category 1 photograph may be inconclusive if the image quality is insufficient.

As illustrated in Fig. 10.7, how well we capture images, such as a latent print or palm print, seen on the physical evidence ultimately determines how well we can process and develop those images digitally. The consequence is that numerous, complex issues are associated with the understanding and proper use of digital imaging technologies.

In addition, Section 4.13.2 Technical Records of the ASCLD/LAB-International Supplemental Requirements (2011 edition) states:

> 4.13.2.3.2—Any change made to completed examination records generated and/or maintained in an electronic form shall be tracked. Examination records shall be considered completed prior to any technical or administrative review of records.

Note: In this context, "tracked" means sufficient information to determine what was changed and who made the change.

In addition, ASCLD/LAB-International Supplemental Requirement 5.8.4.2 to ISO 17025 states that digital photographs of nonrecoverable latent impressions much be treated with the same care and control as the physical evidence itself. In addition, the Council of the European Union adopted a Framework Decision (Council Framework Decision 2009/905/JHA) on November 30, 2009, for the Accreditation of forensic science providers carrying out laboratory activities to ensure that finger mark (aka latent print) laboratory activities could only be carried out by forensic service providers accredited to ISO 17025. The Framework Decision provided that Member States must take the steps necessary to comply with these provisions for latent marks by November 30, 2015.

The key is remembering that the same procedures and guidelines are not always applicable in every circumstance. In addition, the image capture tips and techniques described in this book are neither case-setting mandates nor should they be considered policy directives. The information presented here is to help develop best practices and create policies and procedures based on an understanding of the technology. The goal is to provide information as well as tips and techniques that will enable you to work efficiently and effectively with digital images while ensuring the reliability of those images, thus resulting in more cases solved.

Regardless of whether you are dealing with digital images or digital evidence, it is incumbent upon you to prove beyond a reasonable doubt that the file is true, accurate, and reliable, and that it has not been altered, manipulated, or modified in any way. Secure hash values play a significant role in establishing the authenticity and integrity of digital data/evidence. "Hash Values are popularly known as [the] [f]ingerprint of data and are the crucial single factors which not only authenticate the integrity of data but also play [a] crucial role in the validation of the forensic processes & equipments used for the forensic examination."[5]

Thus, we set the scene: In the beginning was the photograph, and the photograph was good. Right? Not necessarily!

BITS, BYTES, PIXELS, AND DOTS EXPOSED

As mentioned earlier, we have proven to be very willing participants in the development, use, and acceptance of digital technologies. But while the use and acceptance of these technologies have advanced in recent years, the understanding of these technologies has not made the same quantum leap.

For example, walk into a store such as Best Buy and ask two people to explain the difference between the resolution of a digital camera and the resolution of a printer. The resolution of one is measured in pixels, whereas the resolution of the other is measured in dots. What is confusing about that? Everything!

To eliminate some of the confusion and frustration in a meaningful discussion about digital imaging technologies, do not ever use the terms "dpi" and "ppi" interchangeably. These terms have totally separate and distinct meanings. Generally speaking, pixels are square; they appear as a continuous tone; and each pixel represents a unique color value (theoretically, a pixel can be one of 16,777,216 different colors).

RULE OF THUMB 10.2

Dots, on the other hand, are irregular in shape (the degree to which the dot bleeds or is absorbed into the paper depends on the quality and thickness of the paper as well as the absorption rate of the paper, heat and humidity in the room); dots use white space to simulate a specific color value; and multiple dots are used together to represent a single pixel color value.

The terms "dpi" and "ppi" should *not* be used interchangeably because these terms have totally different, distinct meanings.

It is All Bits and Bytes to Me

Adding to the confusion about dots and pixels are two other commonly misused and misunderstood terms:

- Bits
- Bytes

[5]Aarora, Neeraj. "Hash Value: Authentication and Admissibility in Indian Perspective," posted on A Platform to discuss & analyze Financial and Cyber Forensics on May 10, 2013. (See also "Hash Value Tool (Or "Digital Fingerprint") Increasingly Noted in Cases Involving Electronic Evidence," published on Federal Evidence Review (http://federalevidence.com), February 19, 2013.

A **Bit** is the smallest element used by a computer or a digital camera. It can have only one of two values: one or zero (aka "on" or "off"). No other values can exist between these two values. In its most simple, basic form, all digital information is stored electronically in a camera or on a computer as a series of ones and zeros (see Fig. 10.8).

A **Byte** is used to represent the storage capacity of a string of bits such as the byte required to store the value of a single pixel in a digital image. A byte is made up of 8 bits. As shown in Fig. 10.9, a single byte—based upon 8 bits—is used to represent and store a total of 256 different tonal range values, such as 256 different shades of gray ranging from pure black to pure white. Digital images can also be captured and stored using 16 bits per color channel for a total of 65,536 different tonal range values from pure black to pure white. However, 2 bytes are required to store 16 bits of information.



FIGURE 10.8
Inside a computer, a picture appears as nothing but ones and zeros.

Bit	Supporting equation	Possible combinations of 1 or 0
2^1	2x1	2
2^2	2x2	4
2^3	2x2x2	8
2^4	2x2x2x2	16
2^5	2x2x2x2x2	32
2^6	2x2x2x2x2x2	64
2^7	2x2x2x2x2x2x2	128
2^8	2x2x2x2x2x2x2x2	256
2^9	2x2x2x2x2x2x2x2x2	512
2^{10}	2x2x2x2x2x2x2x2x2x2	1024
2^{11}	2x2x2x2x2x2x2x2x2x2x2	2048
2^{12}	2x2x2x2x2x2x2x2x2x2x2x2	4096
2^{13}	2x2x2x2x2x2x2x2x2x2x2x2x2	8192
2^{14}	2x2x2x2x2x2x2x2x2x2x2x2x2x2	16,384
2^{15}	2x2x2x2x2x2x2x2x2x2x2x2x2x2x2	32,768
2^{16}	2x2x2x2x2x2x2x2x2x2x2x2x2x2x2x2	65,536

FIGURE 10.9
This table illustrates how each additional bit doubles the possible number of combinations of 1 or 0, which is expressed in powers of 2. Therefore, 28 would provide 256 possible combinations, or tonal values.

Note: While 16-bit images provide maximum image processing capabilities, 16-bit images require twice as much storage space as 8-bit images. For example, if a 12-MP image is stored as a 24-bit color image (8 bits per color channel), the image file size would be approximately 34.3 megabytes (MB). If the same image was stored as a 48-bit color image (16 bits per color channel), the digital image file size would be approximately 68.6 MB. (Your IT department may be more than displeased if all of your digital photographs are stored on a department-wide server at 68.6 MB per image.)

Most often, people refer to 8-bit color and 24-bit color as the same thing since 8-bit grayscale is typically used to describe the 265 shades from black to white as well as to describe the 256 shades for each color channel—red, green, and blue. Similarly, as shown in Fig. 10.10, 16-bit color and 48-bit color are often used interchangeably to describe tonal value in digital images.

The most common types of imaging sensors used in digital cameras today are charge-coupled device (CCD) or complimentary metal-oxide semiconductor (CMOS) imaging sensor. While based on slightly different technologies, the sensors do the same thing: they convert light into electronic signals into a digital value for each photo sensor, which is commonly referred to as a pixel value.

Today, the imaging sensor in most professional digital single-lens reflex (aka digital SLR or DSLR) cameras have the ability to distinguish between 4096 individual gradients for 12-bit dynamic range or 16,384 individual gradients for 14-bit dynamic range. Some people argue that capturing anything other than 256 shades per channel is a waste of time because the human eye cannot see that many different shades, and many video cards and monitors do not support the display of that many different shades. It should be remembered, however, that applications like Adobe Photoshop have the ability to process up to 65,536 different shades per channel, which can be crucial when trying to suppress background noise.

When the data from the imaging sensor are downloaded (when using a JPG or TIF format), the software in the camera assigns a red, green, *and* blue color value to *each* pixel based on the tonal value (bit depth) of each sensor combined with the color value derived from the color filter array (CFA) that overlays the imaging sensor (demosaicing aka Bayer pattern processing) to create 3 bytes for every pixel in the image.

Using a 6 million pixel (aka megapixel) camera, the noncompressed image size would be 18 million bytes. When converted into megabytes, this would be approximately 17.16 MB.

8-Bit Grayscale

	Number of bits	Tonal Values
	8	256 shades of **GRAY**
TOTAL BITS	*8*	

24-Bit Color

	Number of bits	Tonal Values
	8	256 shades of **RED**
	8	256 shades of **GREEN**
	8	256 shades of **BLUE**
TOTAL BITS	*24*	

48-Bit Color

	Number of bits	Tonal Values
	16	65536 shades of **RED**
	16	65536 shades of **GREEN**
	16	65536 shades of **BLUE**
TOTAL BITS	*48*	

FIGURE 10.10
With 8 bits per color channel, there is a total of 24 bits for color. Similarly, with 16 bits per channel, there is total of 48 bits for color.

When the **RAW Format** option is selected on a digital camera, all processing—demosaicing and assigning RGB color values; noise reduction; sharpening; etc.—is deferred until the image is opened using either the camera manufacturer's image processing software or a compatible application, such as Adobe Photoshop. When data is read and downloaded from the imaging sensor, the data is stored using a proprietary, nonprocessed data format. These proprietary file formats use—on average—slightly more than 1 bytes (8 bits) per pixel (even for cameras that have a bit depth of 12 or 14 bits) is stored for each pixel. Therefore, a camera RAW file from the same 6-MP camera would produce a RAW image file that is approximately 7.1 MB. (Additional file space is required for the metadata, ie, the actual camera settings.)

Before continuing, let us review a couple of points. A digital image is defined as a numerical representation of a physical object recorded electronically in a computer as a series of binary digits (bits), where each bit is either a one or a zero and there are no values in between. A total of 8 bits is used to represent 256 shades of gray, and a total of 24 bits is used to represent 256 shades per color channel. A total of 16 bits is used to represent 65,536 shades of gray, and a total of 48 bits is used to represent 256 shades per color channel. In computer environments, 8 bits equals 1 byte; 16 bits equals 2 bytes of data storage. Using proprietary camera RAW formats, the imaging sensors store data as either 12- or 14-bit grayscale values in a propriety method. Computers can only read data in 8-bit (or 1 byte) increments, as a result the data from the proprietary camera RAW formats must either be truncated during conversion to only 8 bits per channel or padded to 16 bits per channel. Once converted, the data must be written to a separate file using either a TIF or JPG file format. (*Note:* Once the data from the imaging sensor are converted, the converted data cannot be written back to the original proprietary file because only the original camera manufacturer can write to their own file formats.) When images are converted to a 24-bit TIF file format, each pixel consists of 3 bytes of data, to record the brightness, hue, and saturation for each color in the pixel: red, green, and blue. When images are converted to a 48-bit TIF file format, each pixel consists of 6 bytes of data, to record the brightness, hue, and saturation for each color in the pixel: red, green, and blue, so a 48-bit TIF image will be *twice* as large as a standard 24-bit image, and an 8-bit *grayscale* image will be *one-third* the size of a standard 24-bit image.

Are All Pixels Created Equal?

As we just reviewed, when a digital image is captured, the image is digitized into a series of pixels. Each pixel has a specific color value, such as teal, fuchsia, orange, or brown, based on the hue, saturation, and brightness values of red, green, and blue for each pixel. As stated in the preceding section, 8 bits per color channel (24-bit color) provides 256 possible shades of red, 256 possible shades of green, and 256 possible shades of blue for a combined total of 16,777,216 possible color values for *each* pixel in the image.

Computer screens also have a pixel-based resolution, but that resolution has no direct correlation to the pixels in a digital image. For example, standard **Monitor Resolutions** today range from 1024 pixels by 768 pixels to 1920 pixels by 1200 pixels.

This monitor resolution refers to the number of color pixels on the screen, which are also made up using a combination of red, green, and blue light values. (Although meaning the same thing, these light values (aka picture elements) are displayed using different technologies such as LCD technologies, light-emitting diode technologies, gas-plasma technologies, etc.)

The end result is that a combination of red, green, and blue lights coupled with an intensity or brightness value of each individual light creates a display that causes the human eye to perceive a specific color value for the pixels that comprise the digital image.

Let us refer again to the 6-MP digital camera that was discussed earlier. We said that the width of the sensor was 3000 pixels and the height of the sensor was 2000 pixels for a total of 6 million pixels. So how can 6 million pixels be displayed on a monitor that contains only 786,432 pixels (1024 pixels × 768 pixels)?

Simple. Zoom out on the image (reducing the number of individual image pixels that are displayed on the monitor). In other words, instead of viewing every individual pixel in the image, the image is resampled and only one value (resampled average) is displayed for every 2.93 pixels contained in the original image.

RULE OF THUMB 10.3

In contrast, to see more of the actual detail contained within the digital image, zoom in on the image. Zooming into the image too much will cause the image to appear pixilated. For example, viewing an image with only 640 pixels × 480 pixels on a display with a resolution of 1024 × 768 will cause the image to appear pixilated … appear on the screen as large boxes.

Think about the number of monitor resolutions that are available today, and the more common resolutions of digital cameras that are used in law enforcement:

Typical monitor resolutions:

- 1920 × 1200 pixels
- 1680 × 1050 pixels
- 1440 × 900 pixels
- 1280 × 800 pixels
- 1024 × 768 pixels

Typical digital camera resolutions:

- 6016 × 4016 pixels (24 MP)
- 4928 × 3280 pixels (16 MP)
- 3968 × 2976 pixels (12 MP)
- 3872 × 2592 pixels (10 MP)
- 3072 × 2048 pixels (6 MP)

While considering the resolution setting for the monitor, the resolution of the image as well as the video card and/or video driver that supports the monitor must also be taken into consideration. For example, it is possible to have a monitor that is capable of displaying a resolution of 1920 × 1200 pixels, but the video card or video driver cannot support that level of resolution. For example, the video card may support only a VGA connection and does not support a DVI-D or HDMI connection. Or perhaps it does not have a separate graphics processor unit, etc.

In other words, resolution by itself does not imply image quality or size because the same number of pixels can be displayed as a small area (when zoomed out) or as a large area (when zoomed in) on a monitor or printout. For that reason, be careful about enlarging low-resolution images too much on a monitor or printing a low-resolution image too large as well as zooming in enough to see the full level of detail in a high-resolution image.

Do not get hung up trying to figure a ratio of digital image pixels to display pixels because when zooming in or zooming out on the image, the ratio will no longer be the same. Just bear in mind that even a low-resolution image can appear clear when it is displayed on a monitor, or it can appear very ugly (pixilated) if it is enlarged too much on the screen. (Starting to feel like Goldilocks? This one is too big. This one is too small. This one is just right.)

Pixels and Dots Are Not the Same

Previously, we mentioned that a single image pixel is composed of a series of display pixels (on a monitor) that creates an illusion and "tricks" the human eye into visualizing a specific color value.

Similarly, when an image is printed, each pixel is made up of a **Cluster of Dots**. The number of dots in a cluster can vary based on the number of inks used by the printer, which is especially true for inkjet printers. For example, perhaps the printer uses four inks—cyan, magenta, yellow, and black—or a combination of 4, 6, 7, 8, 9, 10, or 12 ink colors. The result is the same for inkjet printers or color laser printers: a series of dots are used to create the illusion of a specific color value, such as wheat, sky blue, or candy apple red.

So how are pixels converted to dots? When an image is printed, each pixel is converted into a series of halftone dots. Each halftone dot is then converted into a series of device dot clusters based on the available ink colors used by the printer, the number of nozzles per print head, the size of droplets, and the type of paper used.

Fig. 10.11 helps to show how this process works.

Please remember that the number of halftone dots used for each pixel and the number of device dot clusters used for each halftone dot will vary on the basis of the type of paper used. Quick-drying, premium photo glossy paper provides a better-quality image than either matte finish or plain paper. With glossy paper, the ink actually floats on the surface of the paper, and because of its quick-drying capabilities, the dots can actually be overlapped. With matte finish or plain paper, the ink cannot be placed as precisely because the ink colors bleed into one another because of the microscopic irregularity of the surface of the paper and the absorption rate of the paper as well as the heat and humidity in the room, and the resulting moisture level of the paper.

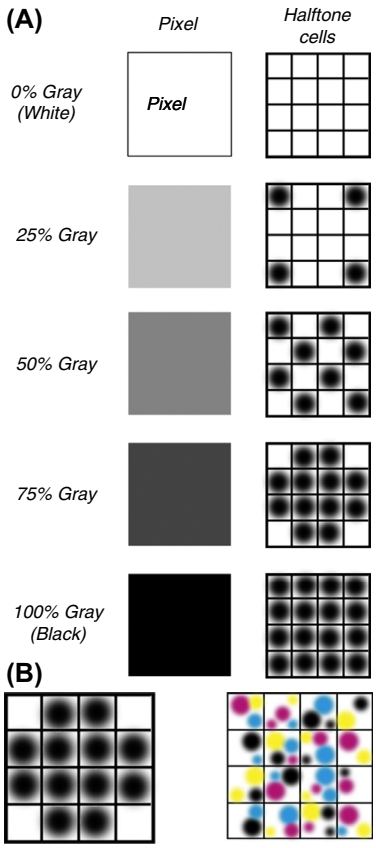


FIGURE 10.11
Pixels are first converted to halftone dots, which are ultimately converted to device dot clusters. (A) Pixels are first converted to halftone cells using a standard 4 × 4 grid. Printing a dot in each grid produces a different shade of gray; leaving all grid spaces empty represents white. With 16 grids available, plus all grids empty, the printer can produce a total of 17 shades of gray. (B) These halftone values are then converted to device dot clusters, which are based on the number of inks used in the printer as well as the type of paper used.

While today's digital cameras match the performance (image quality) of film and computer graphics have achieved the goal of photorealism, printers still do not provide the same level of image quality. In addition, not all types of printers work the same way, and they do not provide the same image quality. However, every printer does have a purpose:

- Some printers provide very good image quality, but at the cost of slow output.
- Some printers provide high-speed output, but at the cost of lower image quality.
- Some printers cost very little to buy, but the cost per print is exceedingly high.
- Some printers have a hefty price tag, but the cost per print is very low.

The moral of the story is that you must decide which printer will fulfill for your specific needs the best. You must determine

- Average number of prints required (output capacity)
- Use of prints (image quality desired for 1:1 prints, crime scene photos, evidence, documentation, and so forth)
- Size of prints (what print sizes are most commonly used, such as 4 × 6, 8 × 10, and 12 × 18)

Then it is just a matter of determining what trade-offs and/or sacrifices you are willing to make. In most law enforcement agencies, the issue boils down to speed and cost versus image quality.

Comparing prints per minute (speed) and costs per print is very easy; comparing image quality can be both subjective and confusing. Although all inkjet printers are rated at a specific dpi, the printer's rated resolution is only one of the elements concerning image quality.

Thus far, I have yet to find a single laser printer that provides the same photorealistic image quality output that is provided by most inkjet printers. Image quality tests can be performed to quantify the output quality for forensic digital imaging.

Regardless of the type or model of printer used, the image quality is still not as good as the traditional film-based photographs used by many latent print examiners for comparison. With traditional photographic prints, there are no dots or pixels that have to be dithered for a clear, precise image, especially if the image is printed as 1:1 life-size image. For example, if a latent print scanned on a flatbed scanner has a calibrated resolution of 1200 ppi, and the output device prints 500 ppi, then the latent print image must be resampled to eliminate a total of 700 pixels. ***This means that more than 50% of the actual pixel information in the image is lost when the image is printed.***

It also means that latent print examiners must either retrain their eyes to use lower-quality images for comparison; to do comparisons on the screen; or to use images printed at 2, 3, or 5 times life size.

Let us consider another scenario: using a 6-MP camera, which has a sensor with a resolution of approximately 3000 pixels wide by 2000 pixels high to capture an area that is 3″ wide by 2″ high, the image would have a resolution of 1000 ppi. Using a dye-sublimation printer that has an output of only 300 ppi, the life-size output (3″ by 2″ printed area) would use only 900 pixels by 600 pixels. In other words, the printer would output approximately 30% of the total pixel values contained in the original image. If the image were viewed at three times its life-size (ie, 3:1), 3″ would become 9″, and 2″ would become 6″. On the basis of an output of 300 ppi, 9″ would contain 2700 pixels and 6″ would contain 1800 pixels, thus providing the ability to see almost every pixel in the image file.

Most laser printers' output values are based on the ability to produce only 17 monotones (grayscale values), as shown in Fig. 10.12. This means that two pixel values can be represented using the same dot pattern even though the pixel values are different. For example, a pixel with a grayscale value of 142 and a pixel with a grayscale value of 130 would be represented by the same grayscale value (halftone dot pattern) of 136. This is problematic for latent print examiners when viewing the output values for a ridge in a latent print with a grayscale value of 142 and the adjacent furrow has a grayscale value of 130. Both the ridge and furrow would be represented on the output using the same dot pattern, thus losing the ability to identify the contrast between the actual values.

An inkjet printer with seven ink cartridges can use the same the 4 × 4 dot grid to produce a total of 119 color tones. Some of the newer inkjet printers use an 8 × 8 grid. With multiple ink colors, varying size droplets, and multipass technology, the 8 × 8 dot grid yields a significantly greater number of color tones. For example, an 8 × 8 grid using three varying size droplets with seven inks would yield a total of 455 color tones.

- 8 × 8 = 64 plus 1 for all white = 65 monotones
- 65 monotones × 3 varying size ink droplets = 195 monotones
- 195 monotones × 7 inks = 1365 possible color values

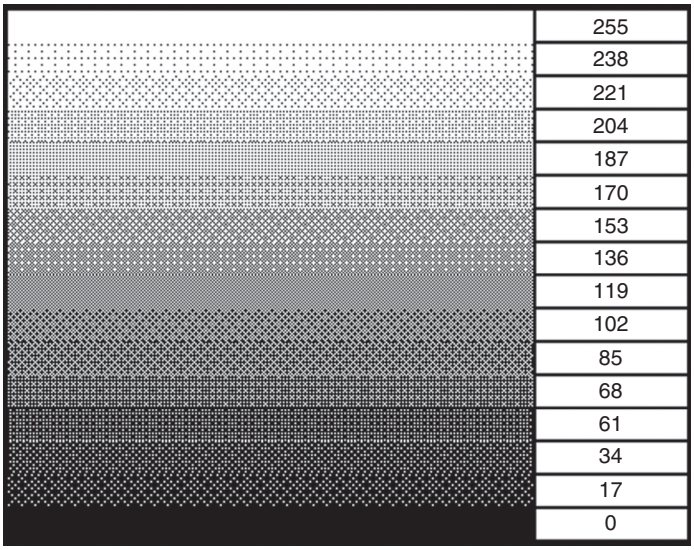


FIGURE 10.12
Since a laser printer can produce only 17 unique shades of gray, it must determine which output value—dot pattern—best represents the actual grayscale value of the pixel. This means that two or more adjacent pixels each with similar but different grayscale values may be represented by the exact same halftone dot pattern, thus losing the ability to see any distinction between the pixels in the printed image.

Studies have shown that the healthy human eye, under optimal lighting conditions, can distinguish somewhere between 16 and 64 shades of gray in a range from black to white. By use of 8-bit grayscale, computers can distinguish 256 shades of gray between black and white, which is approximately four times greater than the ability of the human eye.

Using 8 bits per color channel, there are 256 shades of red, 256 shades of blue, and 256 shades of green; the computer can render a total of 16,777,216 different color combinations for each pixel. Although 1365 possible color tones is nowhere close to the more than 16 million possible shades available, it does produce a nice, picture-quality print.

Ultimately, the trade-off is that a larger dot grid cell block produces more tonal values but has a lower resolution, whereas a smaller dot grid cell block produces a higher image resolution at the expense of tonal quality.

Now that we have the color tonal values defined, we can continue our digital imaging math class and move on to determining approximate dot-to-pixel ratios.

While we do not have an equation we can use to calculate the exact dot-to-pixel ratio, we can, however, determine an approximate ratio of dots to pixels. Please remember that this is only an *approximate* ratio because each printer manufacturer uses its own proprietary algorithm for different paper types, ink droplet sizes, nozzles per print head, different number of inks, and so forth.

As shown in Fig. 10.13, there are typically two resolution specifications: one for horizontal movement of the print head and one for the vertical movement of the paper as it moves through the printer and under the print head. (The lower resolution value is always the vertical movement of the paper through the printer, which is why the image quality of horizontal lines is typically better than vertical lines as demonstrated in Fig. 10.6.)

Moreover, the printer settings—such as image quality, paper type, and high speed—are the actual factors that determine final output quality. For example, the Epson SureColor P400 Wide Format Inkjet Printer has the ability to print an "optimized" resolution of 5760 dpi horizontally and 1440 dpi vertically. If printer settings are not set for maximum image quality as illustrated in Fig. 10.14, the printer will not use its optimized output resolution. Instead, it will print fewer dots, such as 1440 × 720 horizontally and vertically, respectively, thus significantly degrading the output quality of the printed image.

What does all this mean in the real world? To print a copy of a latent impression that is 1″ by 1″ and that has the required resolution of 1000 ppi (in accordance to Appendix F of the FBI's Integrated Automated Fingerprint Identification System Image Quality Specifications) using an output device that has a dot-to-pixel ratio of 300 ppi, the image would have to printed as 3″ and 1/3″ inches by 3″ and 1/3″ because:

- 300 pixels would be printed in the first inch;
- 300 pixels would be printed in the second inch;
- 300 pixels would be printed in the third inch; and
- 100 pixels would be printed in the next one-third (1/3) inch

thus, printing all 1000 pixels.

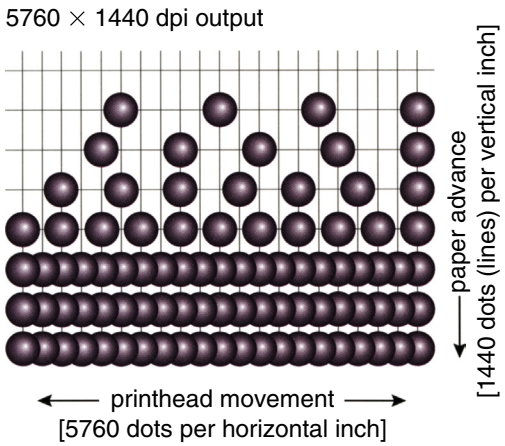


FIGURE 10.13
Output quality is determined primarily based on the physical capabilities of the printer, such as the horizontal movement of the print head as it moves across the paper as well as the vertical movement of the paper as it moves under the print head and through the printer.

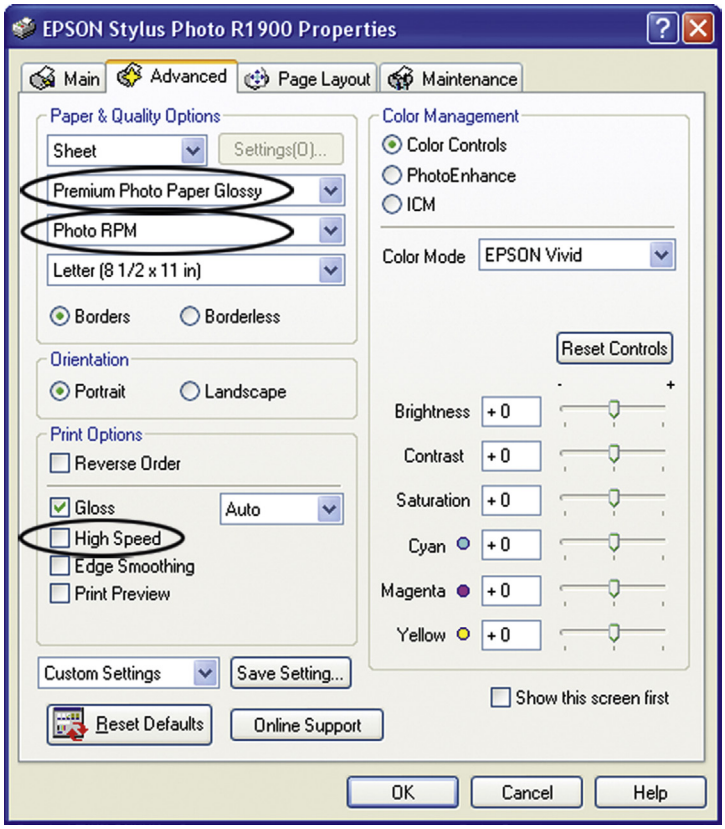


FIGURE 10.14
It is extremely important to select the proper printer settings for maximum image quality. For example, choose the best paper type (Premium Photo Paper Glossy) and the best quality photo setting (Photo RPM), and disable the high-speed option. Choosing other settings, such as Premium Photo Paper Semi-Gloss or Double-Sided Matte Paper, the printer will not print the maximum number of dots horizontally or vertically because these paper types have microscopic irregularities on the surface of the paper, and the printer knows that using the maximum number of dots per inch will cause the wet ink to collect in the valleys of these irregular surfaces and run together, thus changing the hue of the image.

Dye-sublimation (also commonly referred to as "dye-sub") printers are printers of a different color. Dye-sublimation printers actually print pixels, not dots. The color value for each pixel represented is the buildup of the colors contained on the dye-sub donor ribbon. Therefore, it represents an actual color value; it is not made up of dot clusters used in conjunction with white space on the paper. It is for this reason that dye-sub printers are commonly referred to as continuous tone printers.

Unfortunately, most dye-sublimation printers have a resolution of only 300 ppi, which means that the image must be resampled significantly to be printed as a life-size (1:1) image. Using the previous example, if the 1000 ppi image were printed on a dye-sub printer, the output would contain only 300 ppi.

While dye-sublimation printers produce beautiful photo-quality images, these printers do not fulfill the requirements for printed images that require analysis and comparison because of the resampling required to reduce the image resolution to the output capability of the printer. In this case, an inkjet printer can produces a higher-resolution output. The use of dye-sublimation printers was identified as an "example of digital weaknesses" and was one of the reasons to challenge digital evidence and electronic photography.[6]

Note: The proper procedures for preparing impressions for printing will be discussed in the following chapter.

MAKE A STRATEGY FOR THE ENTIRE IMAGING PROCESS

The goal of forensic digital photography is to ensure maximum image quality when possible. It is important to remember that this goal must be considered throughout the entire digital imaging process from input to output.

[6]Cherry, Michael. "Reasons to challenge digital evidence and electronic photography" Informal Opinion. Champion Magazine published by the National Association of Criminal Defense Lawyers, July 2003, p. 42.



FIGURE 10.15
Digital imaging includes input, processing, and storage, as well as output. Miss one element in planning and a big part of the big picture can be lost.

As shown in Fig. 10.15, ignoring one component of this process can create a hole in the big picture. In addition to considering the features of the camera, be sure to consider:

- Image size based on camera resolution and capture format, which affects the number of images that can be stored on the camera's storage medium and on the computer itself.
- Image quality based on type of lens used, such as macro lens or wide-angle lens.
- Processing speed and storage requirements of the PC, including impacts on network performance and throughput if images are being stored on a network server.
- Backup and archiving routines to ensure data security and prevent catastrophic loss of data.
- Output requirements that include life-size (1:1) images as well as enlargements used for court displays.

Once we can define what a digital image is and articulate what image quality and resolution mean as well as explain how these items affect the entire digital imaging process, we will be able to reduce the fear and frustration of the technology and remove the dark clouds of suspicion hanging over the world of digital imaging.

Take a Picture! It Lasts Longer … Or Does It?

Many people have the mistaken idea that traditional film processing provides a higher level of image integrity and they also believe film provides pictures with a longer life span. The truth of the matter is that neither of these are true.

Traditional Negatives Are Losing Quality

Photographs can still be produced from the glass or tin plates used in the photographic processes of the 1800s. Unlike the photographs printed from these negatives originally, the new prints will have a degraded image quality.

Traditional silver halide-based negatives of the past 50–75 years have also begun to fade. The effects of heat and humidity and level of care that these negatives have received affect the quality of the images produced from these negatives.

One type of photograph that has been proven to have a significantly short life span is the Polaroid instant photograph. Many of the Polaroid photographs that were taken during the past 35–40 years will not survive solely because of the materials used in those photographs. To make a long story short, the photographic images that some of us took when we were younger will not last through our own lifetime.

The good news is that images taken with a digital camera will last a lifetime if the images are not lost or deleted. When an image is viewed or printed from an electronic file, the actual data bits used for the print process do not change. Each copy produced from an electronic copy is created using a series of bits (ones and zeros) that will not change from the first copy to the 500th copy.

Negatives, on the other hand, will fade because of the light striking the negative when it is printed over and over again. In addition, the handling that the negative receives will also affect the life span of the negative itself and will jeopardize image quality for the future.

Digital Camera or Flatbed Scanner?

One frequently asked question is: When should I use a flatbed scanner instead of a digital camera?

The first step in choosing which device to use is to determine the size of the object (also commonly referred to as the area of interest) to be captured. This will help determine the final resolution of the captured image and help identify the best technique for capturing the digital images.

For example, using a 6-MP digital camera (with an imaging sensor that has a resolution of 2000 pixels high by 3000 pixels wide) to capture an area for a palm print that is 2″ high by 3″ wide, the resulting digital image would have a resolution of 1000 ppi and meet the required NIST standards. Similarly, capturing an area that is 4″ high by 6″ wide, each inch of the area of capture would occupy only 500 pixels on the imaging sensor, thus no longer meeting NIST standards.

Therefore, on the basis of the size of the object being captured, a digital camera may not provide the desired image resolution for the area of interest.

Scanners, on the other hand, produce digital images that have a constant resolution. For example, if the scanner has a resolution of 1200 dpi and the area being captured is 2″ high by 3″ wide, the resulting digital image would have a resolution of 1200 ppi; the image size would be 2400 pixels by 3600 pixels. Capturing an area that is 4″ high by 6″ wide, each inch of the area of capture would still be captured with a resolution of 1200 ppi: the image size would be 4800 pixels by 7200 pixels.

In addition, scanners use a CCD that has a series of light-sensitive diodes in horizontal rows across the width of the array. Each diode acts like a miniature digital camera in that it digitally samples a specific area of the item on the face of the scanner. Unlike a digital camera, however, each diode on a scanner captures three samples: one sample for red, one sample for green, and one sample for blue. The samples are then "processed" to represent the specific color value of the corresponding pixel within the digitized image.

Note: The resolution of a scan array is commonly referred to as the hardware or optical resolution and is almost always defined in the system specifications as dpi instead of ppi. A more accurate term used to describe scan resolutions might be "samples per inch." The confusion for scan resolutions is caused by the fact that each light-sensing diode is used to create a pixel within the digital image, which is measured as ppi, not dpi. However, when the scanning technology was developed, the scanner was part of another device called a copy machine. This device "copied" an object on the face of the scanner and printed a copy of the scanned object. Since the image quality of the output was measured in terms of dots, the scanning mechanism kept the same definition when it was separated from the printer to avoid confusion at the time. Unfortunately, the times have changed and the way we describe picture elements has changed drastically. But the way we describe scan resolutions has remained unchanged. Plus, there are still "all-in-one" devices that are used to scan, fax, and print, which really causes confusion when trying to identify what the specific resolution is for each function.

In contrast, digital cameras use a similar light-sensitive photoreceptor. However, instead of capturing three values for each sensor, a CFA is placed on top of the imaging sensor in the camera. The CFA contains a series of red, green, and blue filters arranged in a pattern commonly referred to as a **Bayer Pattern**. As a result, the photoreceptor collects only one value: a grayscale value that represents the density of the light striking the photoreceptor filtered by a red, green, or blue color filter. The color value for each photoreceptor (picture element or pixel) is calculated (**Interpolated**) based on the density of the light striking the imaging receptor value together with the values of the eight surrounding neighbor sensors. As illustrated in Fig. 10.16, 50% of the filters on the CFA are green, 25% of the filters on the CFA are red, and the remaining 25% of the filters on the CFA are blue. As discussed in chapter "Digital Image Processing of Evidentiary Photography," the red, green, and blue filters on the CFA not only allow the digital camera to accurately depict color values, but can be tremendously helpful when eliminating background noise that interferes with the image.

Note: There is, however, one digital imaging sensor that does not use a CFA when capturing images: the Foveon imaging sensor. The Foveon imaging sensor uses three separate CCDs, one each for red, green, and blue. While the digital images from the Foveon imaging sensor have a lower resolution, Foveon says the resulting color images are more accurate in terms of color balance and more accurately represent the actual item being photographed. Foveon cites tests in which photographs from digital cameras made by other leading digital camera manufacturers contain moiré patterns, false color values, and so on. Unfortunately, these imaging sensors are available only in limited number of digital cameras that are relatively expensive.

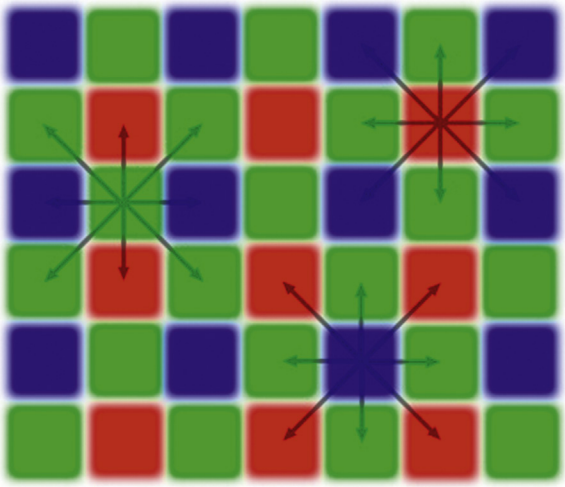


FIGURE 10.16
The photoreceptors in a digital camera capture a grayscale value on the basis of the filtered light density. Therefore, each photoreceptor needs to store only one color value, which is a grayscale value. Color is added when the image is processed or when it is stored on the camera as a JPG image. RAW images are simply the unprocessed grayscale values captured by the photoreceptors. The photoreceptors on a camera sensor capture brightness only, not color. In other words, they "see" only grayscale values based on the red, green, or blue filter. The color value for each pixel is calculated based on the nearest neighbors illustrated by the arrows.

While flatbed scanners have a constant resolution over the entire area scanned, the images produced have a constant light density, which often makes it difficult to eliminate background noise. In other words, the light signal density is the same regardless of whether the pixel is red, black, green, or blue. This makes it extremely difficult, and at times impossible, to separate background colors and relevant image detail when suppressing noise or patterns.

There are no fixed rules about what items should be scanned or digitally photographed. It is just a matter of choosing the device that will work best for the particular scenario based on the type (make, model, and specifications) of the scanner or camera that is available for use; the size of the area of interest; the resolution required, if any, for the image type (category); and the type of digital image processing techniques that will be required.

Best Practices for Digital Photography

Forensic experts in every discipline use digital technologies to capture a variety of digital images every day. The challenge is: How are digital images at the highest possible resolution (quality) captured with the highest degree of accuracy?

Regardless of what type of evidence is being photographed (latent prints, palm prints, bite marks, tool marks, footwear impressions, blood spatter, or tire marks), the goal is to capture the best possible image with the highest possible resolution.

To capture any object with a digital camera with the highest possible resolution, fill the frame with the object and a scale. As shown in Fig. 10.17, image quality is affected both by the size and number of pixels within the image.

Failure to optimize image resolution creates problems when attempting to suppress background patterns, such as backgrounds on checks or money orders where gradient color values are used as a means of security. As the size of the area of capture increases, the camera must be moved further back from the object, and a single photoreceptor must capture a larger area, using all the color values in the area covered by that single sensor and the light intensity to determine the resulting pixel value recorded by that photoreceptor. By capturing a smaller area, the area covered by each photoreceptor is minimized, which also means better color management and a greater opportunity to suppress background patterns and noise.

RULE OF THUMB 10.4

Capturing an area that is too large for the imaging sensor can create moiré patterns, which occurs when multiple colors are "processed" by the camera's optics to create a single pixel value in a grid pattern. In some cases, it may be necessary to take an overall photograph of the entire area of interest and then take separate close-ups of individual areas within the area of interest to optimize image resolution.

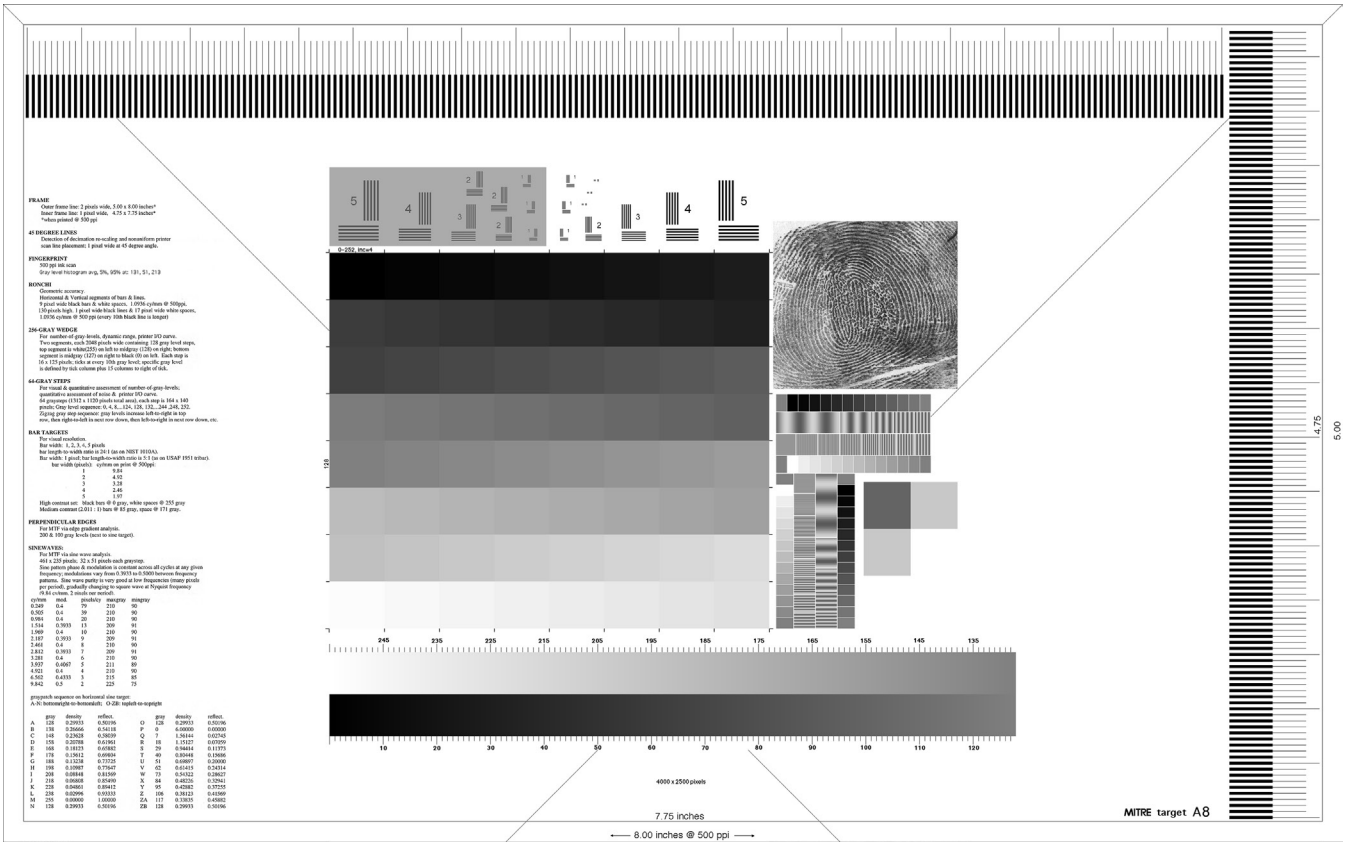


FIGURE 10.17
The FBI Image Quality Test Target was developed by Mitre to help ensure that standards were maintained for measuring image quality. The weakest link in any digital imaging solution is the printer, as illustrated in Figure 11.4.

In digital imaging, resolution and color go hand in hand. The higher the resolution, the better the image quality because resolution helps to maintain color values and keep them separated, and color values provide better image detail.

Capturing Small Objects

When capturing a small object, such as a latent print, palm print, bite mark, or tool mark, set the lens for its closest focusing point. Then, move the camera as close to the object as possible (if the camera is in a fixed position, such as on a copy stand, then move the object closer to the camera), using the distance between the lens to the object as the primary method for focusing. This allows the camera to be as close to the image as possible, filling the entire frame with the object and ensuring the highest possible resolution for image capture. Then, use the focus ring on the lens for fine-tuning the focus of the image.

In addition, it is highly recommended that a high-resolution digital camera be used to capture items such as latent prints, palm prints, bite marks, or tool marks. A 6- to 8-MP digital camera to capture single latent print impression, but a higher-resolution camera, such as a 10- to 12-MP camera will still be required for capturing sequential prints and/or palm prints.

To determine the maximum capture area for a particular digital camera, simply divide the effective pixel resolution of the camera—both width and height measurements—by 1000. (This is the minimum image resolution to be compliant with the FBI NIST standards for latent prints and palm prints. While there is no comparable standard for bite marks, tool marks, etc., this is a pretty good rule of thumb for these types of objects as well.)

For example, using a Nikon D700 to capture an area that is approximately 4.25″ by 2.8″ based on an effective resolution of 4256 pixels by 2832 pixels. However, capturing a smaller area will increase the resolution, which means that the image will be easier to process, should it require processing to make the image suitable for comparison purposes.

Once the image has been captured, the scale in the digital image will be used to calibrate the image for accurate one-to-one, life-size output. This process will be discussed in the following chapter, titled "Digital Image Processing of Evidentiary Photography."

Capturing Larger Objects

There are also some experts in the field today who state that a resolution of 300 ppi is a sufficient resolution because there are no printers that can print images with a resolution of greater than 300 ppi. However, following the proper procedures and use the appropriate digital camera *and* the appropriate printer, digital technologies can be used for the capture, analysis, comparison, and output of footwear impressions and tire marks very successfully.

A common misunderstanding about the use of digital technologies to capture large objects, such as footwear impressions, tire marks, bloodstains, etc., is that the entire object must be captured in a single image. While this is true, the overall image is not the sole requirement for analysis and comparison. As discussed earlier, the larger the area captured with a digital camera, the lower the resolution of the digital image; conversely the smaller the area captured, the higher the resolution of the digital image. To capture an image with greater detail, it is totally acceptable to photograph the image as smaller segments. Segmentation is very important in some instances, especially when photographing large palm impressions or shoe impressions where a loss of detail/accidental characteristics occurs when the photographer chooses to capture a larger area, thus having an image with a much lower resolution/lower image quality.

Even with all the sophisticated tools and features in Adobe Photoshop today, the image quality of a low-resolution image *cannot* be improved. That only happens on *CSI* … and that is television. The most anyone can hope to accomplish with a low-resolution image is to make it look less ugly by increasing the image resolution. But adding pixels to increase quality is also an issue with courts. What pixels did you add? Where did you add them? (It is not as pretty as putting lipstick on a pit bull, but it is close!)

One major consequence of trying to capture an area that is too large with a digital camera is that the optics in the camera blend multiple color values (from multiple source elements) together as a single pixel. In addition to losing detail and sharpness in the image, other problems are created, such as moiré patterns. When in doubt, always take an overall picture of the object to provide a reference to address questions about the position or location of the item of interest. Then, take as many close-up pictures as are needed of individual areas of the object or area of interest.

When taking pictures of objects, such as footwear impressions, tire marks, and bloodstains, capture the image in segments, allowing for at least a 1″ to 2″ overlap in each segment. Once the images are calibrated, the images can be stitched together to create a single image using the full-length image as proof that the print existed as an entire (whole) object.

Note: It is imperative that latitude and angle be maintained in all segments. Failure to maintain the same position and angle will compromise the integrity of the stitched image.

Law enforcement agencies in Nebraska, Iowa, and Alaska have successfully used high-resolution, stitched images for more accurate and reliable analysis of footwear impressions and tire marks in court. Alternatively, other agencies have used the low-resolution "overall" digital images together with high-resolution digital images of specific areas of interest in the footprint or tire tread.

RULE OF THUMB 10.5

If photographing large areas as segments for the purpose of capturing a high-resolution image for analysis, it is important to allow at least a 1" to 2" overlap in each segment. In addition, do not attempt to capture large areas such as footwear impressions, tire marks, or bloodstains with anything less than a 12-megapixel digital camera. And last but not least, do not capture a large area of interest using a camera JPG format and then hope to do any type of analysis or comparison with that image later.

Note: Mitre developed the test target shown in Fig. 10.17 for the FBI to assess image quality for comparison purposes. This test target is based on a required minimum resolution of 500 ppi to quantify both pixel and spatial resolution (to identify how close lines can be to each other and still be viewed and printed as separate, distinct lines). This means that the image must be captured with a resolution of at least 500 ppi as well as printed with a corresponding dpi image quality capable of producing both spatial and pixel resolution of 500 ppi.

When digitally capturing footwear impressions, tire marks, or blood spatter, use a high-resolution digital camera, such as a 12-plus-MP digital camera. For example, the Canon EOS 7D, with a resolution of 5184 × 3456, would capture an area that is approximately 10.5″ long by 7″ wide while maintaining a resolution of 500 ppi. While this camera has a high resolution, it also has a small imaging sensor (22.3 mm × 14.9 mm), which is less than a standard 35 mm frame size (36 mm × 24 mm). The small imaging sensor can cause distortion in the digital image because of its 1.6 focal length multiplier. The Canon EOS 5D Mark II digital camera is a 21-MP camera with a resolution of 5616 × 3744 using a standard 36 × 24 mm imaging sensor, which provides a focal length multiplier of 1. This means that an area that is approximately 11.25″ wide by 7.5″ can be captured without lens distortion.

In the end, when capturing large areas, such as footwear impressions, tire tread impressions, or blood spatter properly, use a camera that has an imaging sensor with the lowest possible focal length multiplier! The following list displays the more common imaging sensor sizes and their respective focal length multiplier:

- 18.7 × 14 mm (1.8× focal length multiplier)
- 22.3 × 14.9 mm (1.6× focal length multiplier)
- 23.6 × 15.7 mm (1.5× focal length multiplier)
- 36 × 24 mm (1× focal length multiplier)

THE SCIENCE OF DIGITAL IMAGING IS GETTING A BIT DEEPER

As discussed earlier in this chapter, the dynamic range of shades per color channel ranges from 8 to 16 bits for a flatbed scanner, or 12 to 14 bits for digital cameras.

Capturing images with a greater bit depth not only optimizes image quality, but also optimizes the ability to eliminate backgrounds and so forth during image processing. For example, having an image with a higher bit depth often can help identify separate color values that are very similar, such as a ninhydrin print on a check that uses a similar color value for the check background, identify overlapping fingerprints, or notice very light detail contained in a poor-quality latent fingerprint.

The higher bit depth (aka higher dynamic range) made a critical difference in another case where a latent print was found in blood on a shirt that had been processed with Amido black. The shirt was white with black and blue stripes, and the ridge detail also appeared as dark blue values because of the Amido black process. With only 256 shades per color channel, the black and blue stripes could not be removed without affecting the ridge detail; however, with 4096 shades per color channel (available because of the 12-bit color depth available in the RAW file), it was easy to eliminate the black and blue stripes successfully without affecting the ridge structure of the latent print.

So let us do one more quick review before continuing. Using a digital camera with a high dynamic range provides the ability to suppress background colors or other noise within an image. However, to take advantage of the high dynamic range in a picture, the image must also have a high resolution (ppi). Be sure to use the appropriate lens that allows the object to be as close to the lens as possible. If the object is too far from the lens, the imaging sensor will have problems separating the detail between pixels, which means the image may appear fussy or out of focus.

While tools like Adobe Photoshop can do many things to fix a lot of photographic issues, the appropriate standards and guidelines must be followed carefully for capturing the best possible image. Contrary to popular belief, Adobe Photoshop cannot turn a proverbial pig's ear into a silk purse. Put another way, the possibility of enhancing, analyzing, and comparing forensic evidence begins with capturing good, high-quality images.

Image S&M—Storage and Management of Digital Images

To genuinely appreciate digital image quality, we must also consider:

- The size of the imaging sensor (CCD or CMOS chip)
- The size and number of photo cells on the sensor
- The size of the area (object) being acquired

Most digital camera manufacturers share a common goal: They want to provide a higher resolution (more pixels), a wider frame coverage (larger CCD/CMOS sensor), and additional features at a lower cost to satisfy the wants and needs of the consumer market. In most instances, the wants and needs of the consumer market, which drive the development within the industry, do not fulfill the needs and requirements of the forensic community.

In fact, many digital camera manufacturers try to place more photo cells onto imaging sensors that are smaller than the fingernail on your little finger. In contrast, several proconsumer digital SLR cameras have imaging sensors that are the same size as a standard 35 mm frame or even larger.

To put more receptors on a smaller imaging sensor, digital camera manufacturers make the individual photo cells smaller (approximately 3–4 μm in size vs the typical 6- to 10-μm size of the individual photo cells in a digital SLR camera). Unfortunately, these smaller photo cells have reduced sensitivity to light, have lower dynamic range, and are more susceptible to **noise**.

Smaller photo cells are also subject to diffraction (a type of distortion that makes the image look smeared because of light spreading out from a small sensor) and other undesirable secondary effects.



FIGURE 10.18
In digital cameras, the color value for each pixel is interpolated on the basis of the filtered light density of the neighboring sensors.

As shown in Fig. 10.18, both the number and size of pixels can effect image quality significantly.

Be aware that the pixel count (resolution) and the imaging sensor size are not tied together. It is very common to find digital cameras with a higher resolution and a smaller imaging sensor while other digital cameras have a lower resolution and a larger imaging sensor. With digital cameras that use interchangeable lenses and have an imaging sensor that is smaller than a standard 35 mm frame (36mm × 24 mm), pay special attention to the focal length multiplier. This value is used to determine the effective range of the lens in use. The higher the focal length is also an indicator for other potential (distortion) problems as well.

Many digital camera users further degrade image quality by use of compressed file formats such as JPG to store larger volumes of pictures with limited storage space and use compressed file formats so the camera will operate faster. Unfortunately, high speed and image quality do not go hand in hand. Like printers, digital cameras cannot provide high speed and maximum image quality at the same time: One suffers at the expense of the other. For faster performance, minimize the image quality and use compressed image files; for better image quality, expect longer download times and larger files.

Image Formats: Joint Photographic Expert Group Versus RAW Versus Tagged Image File

After three decades digital technology awareness, one would think there would be an agreement on something as simple as image format. But that is not the case. But then again, this should not be a total surprise either because people *still* do not know the difference between a dot and a pixel. The choice all comes down to opinions, and everyone has one. The winning opinion is typically that held by the person with the greatest degree of control, which does not always interpret to the person with the highest authority. (In most law enforcement agencies, the IT department holds winning opinion about almost everything digital.)

Most digital cameras store images in one or more of three primary image file formats:

- JPG (Joint Photographic Expert Group)
- RAW (camera raw (read unprocessed) sensor data)
- TIF (Tagged Image File)

Some camera manufacturers also provide the ability to save images simultaneously in both RAW and JPG formats. And now, some newer cameras have the ability to store RAW files using downsampled (reduced) resolutions. While this latter technique does not affect image quality as much as the variable rates of JPG compression, it can affect overall image quality depending on how the image is to be used.

JOINT PHOTOGRAPHIC EXPERT GROUP

JPG (also referred to as JPEG) is the most commonly used (or misused) digital camera image format.

When a picture is taken with a digital camera, the image sensor uses the camera's settings, including, but not limited to, white balance, sharpness, and hue and saturation to process the actual image data. Once the actual imaging sensor data have been downloaded from the sensor and processed internally in the camera, the processed color values are then compressed and the file is then stored.

Size does matter when it comes to the space required to store digital images as well as the time it takes to download and open digital images.

Of the three file formats, JPG provides the smallest file size. Because of its smaller size, it is also the fastest to download both from the sensor in the camera to the camera's storage media and the fastest to download when moving images from the camera (or the camera's memory device) to the computer. Most digital cameras provide multiple image quality (compression) settings, such as fine, normal, and basic. Depending on the processor speed, memory, and software within the camera, some digital cameras actually compress images more than others. For example, images generated from the highest JPG setting in some digital cameras are difficult to distinguish from their uncompressed counterparts.

Therefore, some people believe that a JPG image provides outstanding image quality (or at least "good enough" image quality) while delivering the fastest speed for all camera functions with the least amount of storage required. There is no such thing as a fast, high-resolution lossless compressed image format.

As demonstrated in the pictures in Fig. 10.19, JPG compression removes features; relocates boundaries; alters the size, shape, and color of features; and reduces resolution differently for different locations in the same image. This process also alters pixel values differently, depending on whether they lie at the center or boundaries of the pixel grid into which the image is divided. This produces **artifacts** and loss of details that are not consistent and cannot be predicted.

Most, if not all, JPG algorithms are based on a standard 8-pixel-by-8-pixel grid in which a Fourier-related transform is used. Depending upon the frequency components of the values in that block, several types of clearly visible artifacts that include, but are not limited to:

- Ringing (artifacts caused when there are sharp transitions within the block, which is particularly visible around text in pictures)

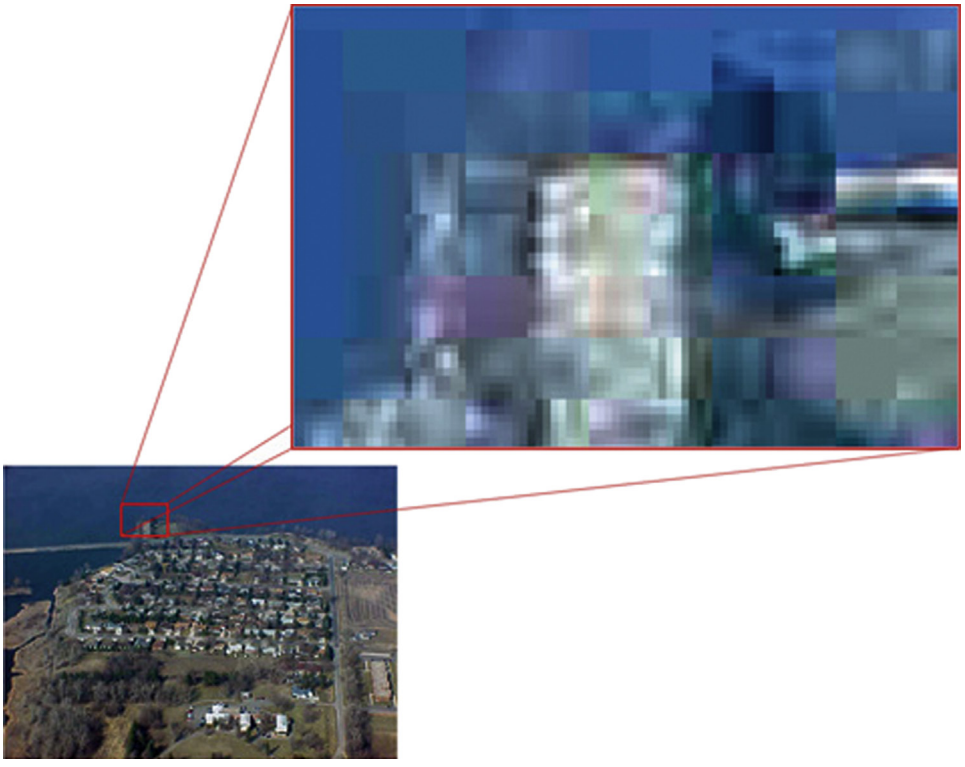


FIGURE 10.19
Image quality can also be affected by pixel size, as well the number of pixels within an image. Zooming in too much on a low-resolution compressed image shows the boxy artifacts caused by resampling.

- Posterizing (artifacts caused when portions of the original image with a gradual transition are replaced by abrupt changes in shading and gradation from one area of tone to another)
- Staircase noise (aliasing) along curving edges
- Blockiness (also called checkerboarding)

Although high-speed capture and rapid file saving on the camera might be useful for photographing a sporting event such as WWF Knockdown or a NASCAR event, it is *not* important for photographing footwear impressions, tire marks, latent prints, or blood spatter at a crime scene.

In addition, almost all digital cameras offer three different JPG image quality options. As was mentioned earlier, most cameras provide fine, normal, or basic image quality options for saving JPG images. The fine image quality option keeps more of the actual image data (less lossy compression), and basic keeps the least amount of image data (very lossy compression).

Many people do not realize that many JPG compression algorithms do not actually remove the pixel during compression; it simply discards the pixel's color value. (In other words, the pixel is a mere shell of itself.) For example, a 6-MP camera (3000 × 2000) stores approximately one-third of the actual pixel values, resulting in a file size slightly less than 2 MB. When the image is decompressed (when it is opened) the file is returned to its former 6-MP size, which yields an RGB image that is approximately 17.2 MB in size. The "restored" pixel color values are based on the sampled pixel values that were actually kept during the compression process.

Because of all the compression and decompression, do not use a JPG format to save an original image that must be processed later. For example, saving pictures of shoe prints in a JPG format can cause artifacts that would preclude the visualization of unique details such as wear patterns.

Similarly, pictures that are captured and stored initially as JPG images should be saved as TIF images after they have been processed so they will not be recompressed when they are resaved. Typically, this conversion is done immediately (using the "Save As" command) on opening the file in Photoshop before any enhancement processes are initiated. (Once again, be aware that once the original image data from the camera sensor has been lost—when the image is saved by the camera as a JPG file—the original pixel values can *never* be recovered. The pixel values that are created when the image is opened and decompressed are nothing more than an approximation of what existed before.)

Another problem experienced with JPG images is that every time a JPG image file is opened, a single pixel in the image is changed, and then the image is resaved, the entire image is recompressed. More specifically, when a series of enhancements are made in a JPG image, and the image is resaved after each step, the image is recompressed after each step. As a result, the image becomes more and more degraded with each successive resave. Therefore, always save processed files using a truly lossless format such as TIF format.

When saving a JPG image during the image editing process, the on-screen image will not reflect the data that are actually stored for that image. To view the actual stored image data, close the image after it has been saved and then open the newly saved image.

Even though JPG compression discards original pixel values, some crime scene photographers still argue that enough detail is retained that the remaining detail is sufficient for crime scene photographs. (More often than not, they also use the highest level of compression to make the smallest possible file, which unfortunately does the greatest amount of damage to the image.)

As stated earlier in this chapter, most crime scene photographs are considered "documentation" because they are not used for detailed analysis. As a result, it is acceptable to capture and store crime scene photographs using a JPG format. But when using a digital camera to photograph items at the crime scene, such as latent prints, footwear comparisons, etc., do not use a JPG file format.

From a technical perspective, once the original pixel information is discarded during image compression, the original information *can never be restored* when the image is decompressed for viewing or editing; the restored pixel values will be only an "interpretation" of the discarded data, which is why a JPG format should never be used compress any digital image that must be restored precisely as captured by the imaging sensor.

Always remember that the higher the rate of compression, the smaller the file size, which means that more data are lost and more compression artifacts will be visible; the lower the compression rate, the larger the file size, which means that less data are lost and fewer artifacts will be visible. The most common side effects of JPG compression are moiré patterns appearing within the image and blocking artifacts.

There are, however, JPG compression algorithms that are less lossy and even near lossless. JPG 2000 is an algorithm that provides an almost lossless data stream. Unfortunately, JPG 2000 requires complex encoders and decoders. Visually, JPG 2000 may produce "ringing artifacts" that often appear as blur or rings near edges in the image. While JPG 2000 has been published as an ISO standard (ISO/IEC 15444), JPG 2000 is not widely supported in web browsers, nor is it supported by digital camera manufacturers and other software developers.

What are the advantages of using a JPG format?

- JPG images require less space not only on the camera media, but also on the computer.
- JPG images are processed inside the camera, and they do not have to be converted to be viewed or opened.
- JPG images not only provide faster processing on the camera, but can be downloaded and viewed on a computer faster.
- JPG images are based on a standardized format, which means they are compatible and can be shared easily.
- JPG images are smaller and can be transmitted easily in e-mails as well as imported into word processing files (for reports) and PowerPoint presentations (for courtroom presentations) much easier. (Document files are much smaller, as are PowerPoint files, but the use of JPG files in PowerPoint presentations also enables slides to be displayed much more rapidly.)

In many instances, the advantages of the JPG format outweigh the disadvantages. Disadvantages include the following:

- JPG images have a lower dynamic range (only 8 bits per color channel or 256 shades per color channel).
- Images are compressed by discarding actual sensor data (exact pixel values cannot be recreated as they were originally captured—they are simply an interpretation of the original pixel values).
- Each time a JPG file is opened, processed, and then *resaved*, the image is recompressed, which causes even more data loss. (Simply opening, viewing, and then closing a JPG file without making any changes does *not* have any effect on the stored image file).
- Resampling techniques are used to restore discarded pixel values when digital images are decompressed for display and/or printing. Depending on the level of compression used when the image was saved, the resampling techniques used to decompress the image often cause image degradation commonly referred to as "blocking," as shown in Fig. 10.19.

RAW (Which Literally Means Unprocessed "RAW" Image Data)

A number of digital camera manufacturers also provide a camera RAW format as one of the methods for storing images on the media inside the camera.

These RAW camera files are simply the unprocessed sensor data. The good news is that the RAW files are smaller than a noncompressed TIF file, but they are larger than a JPG because none of the actual sensor data are discarded during compression.

The bad news is that RAW image files are actually data files that must be processed before they can even be viewed. For example, the images must be processed using a RAW image file converter (one is typically included with the software purchased with a digital camera) to view images captured by that camera in a RAW format. Software applications, like Adobe Photoshop, have a RAW image converter built into the application and can open files from most, if not all, of the more commonly used digital cameras.

Upon the RAW image file opening in the converter window, white balance, temperature, exposure compensation, brightness, contrast, sharpness, lens aberration, and hue and saturation can be adjusted. With all this flexibility comes a higher level of complexity. Because some people do not like to fiddle with the RAW options, they argue that JPGs can provide a better image easier because the JPG file uses the camera's white balance and sharpening settings when the picture is taken. No post processing of the JPG image is needed just to open the image.

Many forensic photographers prefer to use the RAW format because they have the power to adjust the various parameters to produce the image quality and tone that they desire. In fact, most photographic problems—except focusing, of course—can be addressed when converting a camera RAW image file.

In addition, all the camera manufacturers state that their proprietary RAW format delivers an image that is superior in quality to that of their competitors. Because these proprietary formats store information in a different manner, they must use different file extensions to identify which format they are in, such as *.CRW, *.NEF, *.RAF, *.ORF, *.MRW, *.DCR, etc.

The advantages of using RAW files over JPG or TIF files include the following:

- RAW files are smaller (in size) than TIF, yet they do not discard any of the actual light values captured by the imaging sensor.
- RAW files are stored in their native 12- or 14-bit grayscale mode (4096 tonal range values and 16,384 tonal range values, respectively) compared with only 8-bit grayscale values (256 tonal range values) used to store JPG files.

Note: While the camera stores the original 12- or 14-bit values as a data file, the corresponding image files must be stored as either an 8-bit or 16-bit image. This means that the RAW tonal range values for each pixel are either discarded when the image is opened as an 8-bit image or that the remaining bits (4 bits for a 12-bit image and 2 bits for a 14-bit image) are padded with null values to fit in the file space allocated for a 16-bit image. Camera utility programs that convert their RAW files to TIF or JPG automatically truncate the tonal range values to the standard 8 bits or 256 shades per color channel.

- RAW files are not processed within the camera; all processing is deferred until the file is opened on the computer.
- RAW files are read only. All changes made during the conversion process, such as the white balance, brightness and contrast, etc., are written to an XMP "sidecar" file. Since the original RAW file cannot be altered, RAW files are preferred by the courts compared to image formats, such as JPG, where the original file can be altered easily.

RAW files are approximately one-third the file size of a noncompressed TIF image and can be written to the camera's storage medium faster than a TIF file. In addition, they can be downloaded much faster than TIF files from the camera storage media.

Disadvantages of using RAW files include the following:

- RAW files cannot be shared easily because RAW file formats are not standardized, which means that the recipient may not be able to open the files. Currently, most camera manufacturers use a proprietary RAW format; therefore, the compatibility between individual camera models and imaging software is also limited. Adobe Photoshop CS and later versions have included seamless, integrated RAW file conversion for most digital cameras.
- The computer does all the processing rather than the camera. This means that not only must the original RAW file be stored, but also the converted file and in many instances the processed (enhanced) image file. Maintaining the relationship between all these files can be troublesome, not to mention the challenges related to storing and retrieving the images.
- Accuracy of tonal range can be argued, especially in the case of bruising. For instance, in domestic violence or sexual assault cases, the person processing the RAW files may not have been the person taking the pictures. Because the person opening the file can adjust the hue and saturation subjectively, the true nature of the picture has the potential of being compromised.
- Software developers such as Adobe and Microsoft have developed digital imaging applications that include their proprietary RAW file conversion utility. Because they handle adjustments such as temperature, hue, saturation, lens aberration, and so forth differently, the color values, contrast, and sharpness potentially may be processed differently by the different software applications.

TAGGED IMAGE FILE

Over the years, **TIF** files (also referred to as TIFF, which is short for Tagged Image File Format) have been identified as "the truest interpretation of an image." However, this description is only partially true.

In the past, some digital camera manufacturers, such as Kodak, used a proprietary file format with a TIF extension as part of their naming convention. Unfortunately, these TIF files could not be viewed or processed as TIF files without the use of Kodak's proprietary software. This caused a great deal of confusion and frustration because TIF files are supposedly compatible with most imaging applications and operating systems. The Kodak TIF files were neither. (With the standardization of TIF and JPG file formats, camera manufacturers no longer use the TIF extension for images stored using a proprietary file format.)

Advantages include the following:

- TIF is the most accurate and reliable method for storing processed images that were captured as either RAW or JPG.
- TIF files can have multiple layers (including as Adjustment Layers and/or Smart Layers that are now available in Adobe Photoshop).

- TIF is the most reliable format for storing digital images that have been processed when forensic image analysis and comparison is required.

Disadvantages include the following:

- Large files require vast amounts of storage space and significantly more time to download.
- Large files cannot be shared easily across the Internet.
- Large files require more time to print.

As mentioned earlier in this chapter, SWGIT makes a distinction in the file formats used for Category 1 and Category 2 images. SWGIT recommends that evidentiary photos (Category 2 images) should be captured using either TIF or RAW file formats, whereas photographs used solely for documentation purposes (Category 1 images) may be captured and stored as JPG files.

Note: SWGIT changed the "requirement" to capture images as TIF or Camera RAW because a latent print identification was challenged in court when a local agency submitted a JPEG image for latent print processing, analysis and comparison. The Court cited the SWGIT guidelines on the position that "thou shall not use JPEG." The print had plenty of detail to make the identification. As a result, SWGIT change the guideline to avoid having evidence thrown out of court that is still usable.

In the subject case, the image contained sufficient detail that allowed the latent print examiner to make a positive identification. However, the examiner could not articulate or elaborate on the technology to allay the Court's concerns about compression artifacts even though the image was compressed using a less lossy compression algorithm, which did not incur a significant loss of detail; therefore the image was still of value. It should also be noted that one of the contentions put forth by the FBI in an effort to explain the fingerprint misidentification in the Brandon Mayfield case was because the image submitted by the Spanish police was a poor quality, compressed, JPG image.[7]

One would think—and hope—that image quality would win out over smaller, less accurate formats, but it has not. While most law enforcement agencies make a distinction between evidentiary (analysis required) and documentation photographs, many do not. Many IT departments in both large and small law enforcement agencies mandate that photographs will be captured and stored using JPG format solely because of the numbers of images now being taken with digital cameras at the crime scene and in the lab and the corresponding space required on the department server to store those images. It is clear that those individuals do not have to put their career on the line using inadequate images. (Think about how you might feel if you could not solve a case just because the digital images of the latent prints in the case were not good enough; or how you might feel if a family member was raped or murdered because poor quality images prevented a thorough analysis of the evidence and failed to lead to the identification of a serial rapist or murderer.)

RULE OF THUMB 10.6

The need for the best possible image quality—both capture and output—should always prevail in any argument. However, the reality is that the argument for better images does not always win, and crime scene technicians, firearms examiners, latent print examiners, etc., have to deal with less than acceptable images. There really is no substitution for good photography and good image quality!

After enhancing an image, digital images must be saved using a lossless compression format such as TIF, because compression formats, such as JPG, will degrade the image.

Image Processing (the Process Formerly Known as "Enhancement")

As described at the beginning of this chapter, photography lost its innocence many years ago. Photographs have been retouched by use of a number of manual techniques since the 1800s.

With the availability of high-resolution digital cameras; fast, powerful personal computers; and sophisticated photo-editing software, the manipulation of digital images has become more common. We have all seen the marvels (commonly referred to by defense attorneys as manipulations) created by computers for movies and the hoaxes that have

[7]US Department of Justice, Office of the Inspector General. "A review of the FBI's Handling of the Brandon Mayfield Case," Unclassified Executive Summary, January 2006.



FIGURE 10.20
This hoax photograph showing an airliner approaching the WTC on 9/11 was seen around the world.

arisen through image manipulation. One of the many popular hoaxes was the photograph (shown in Fig. 10.20) that was supposedly taken by an individual on top of the World Trade Center on 9/11.

The forensic community not only has to deal with the "CSI effect" caused by television shows, but also the numerous problems caused by digital photo manipulations commonly referred to as "Photoshopping" by the media. To make matters worse, "I 'Photoshopped' the image" has become a common phrase among casual Photoshop users as well as professional photojournalists and the media. Consequently, the issue of ethics plagues the forensic community because there are dozens of examples of photographs in which the authenticity has been questioned because of image manipulations. Sadly, many of these image manipulations are not even done well, and it is obvious even to the casual observer that the images have been manipulated.

As a direct result of these and other questionable digital manipulations, the law enforcement community has found itself under scrutiny by the judicial community about the admissibility of digital images in the courtroom. For example, a state legislator took the extreme position in 2003 Wisconsin Assembly Bill 584, which "prohibits the introduction of a photograph … of a person, place, document … or event to prove the content … if that photograph … is created or stored by data in the form of numerical digits." As a result, digital images were not admissible in Wisconsin courts for a number of years solely because a legislator was upset about high school kids manipulating digital photographs by putting heads on the bodies of the opposite sex.

Many law enforcement agencies and prosecuting attorneys are concerned about converting to digital imaging technologies because of misleading opinions expressed in articles such as "Reasons to Challenge Digital Evidence and Electronic Photography" by Michael Cherry and "Fingerprint Evidence in the 21st Century" by Edward J. Imwinkelried and Michael Cherry published by the National Association of Criminal Defense Lawyers. Other informal opinions, such as the editorial titled "Beware the Pitfalls of Digital Evidence" by Scott Christianson and articles such as "Digitized Prints Can Point Finger at Innocent" published in the *Chicago Tribune*, still feed the controversy yet today.

How can this technology withstand the charges of impermissible tampering with the original image to produce images that are not "clear and accurate representations of the original scene"? Just because we have the technology at our fingertips to do some pretty remarkable manipulations of images does not mean that all our images will be altered or manipulated in some way. Admittedly, much of the skepticism revolves around the lack of knowledge about and the lack of training in the technology.

Film negatives have always been subject to many of the same manipulations that are now the focus of digital imaging critics. A skilled darkroom technician can do miracles with a negative. Yet, it has been extremely rare for traditional photographs to be challenged and excluded from the courtroom. Why? Because, if necessary, the darkroom technician can come to court to testify that no illicit tampering was done during the development and printing process.

In the past, the admissibility of traditional photography simply rested on the integrity of the photographer and the darkroom technician. The same criterion is now being applied to the admissibility of digital imaging; however, we have not achieved this lofty goal. A general fear factor is that technology allows for the possibility of manipulation; therefore, many defense attorneys want the jury to assume that an image has been tampered with even though the individual presenting the digital images in court testifies under oath that no such manipulations were done to any images being offered in court as evidence.

In accordance with the Rules of Evidence, it is generally held that unless provided otherwise, relevant evidence (that has probative value) is admissible in proceedings. Evidence that is not relevant is not admissible. Once the evidence is submitted, the issue turns to the "weight" to be given to the evidence. For example, the issue of not being able to provide an original image does not, in and of itself, preclude the image from being admissible. The weight of the evidence (believability) depends upon the persuasiveness of the person testifying about the authenticity and integrity of the evidence as well as what was done to the image.

It should also be noted that there are only a very few cases (only two that I know of) that have been tried that directly address the admissibility of digital images. One of the key cases that is referenced when the issue of the admissibility of digital images arises is the State of Georgia versus Mastro Almond. In this the Georgia Supreme Court affirmed the lower court's decision that the prosecution properly authenticated them as "fair and truthful representations of what they purported to depict," and that there was no authority for the proposition that the procedure for admitting pictures should be any different when taken by a digital camera.

It should also be noted that there are only a very few cases (only four that I know of) that focused on the admissibility of digital image processing:

- State of Washington versus Eric Hayden
- State of Florida versus Victor Reyes
- State of California versus Phillip Lee Jackson
- People versus Perez (California)

In all of these cases, the courts held that (1) there does not appear to be a dispute among qualified experts as to the validity of enhanced digital imaging performed by qualified experts using appropriate software; (2) that the process is generally accepted in the relevant scientific community; (3) that the process did not alter the image; and (4) that "new information" was not added to the image.

So, permissible digital imaging techniques are those processes that enable the image to be visualized more clearly and reliably. Best practices require that both the original and processed image file be provided to prove that (1) nothing material or essential has been added to the original image and (2) nothing material or essential has been removed from the original image.

RULE OF THUMB 10.7

Unfortunately, many people are skeptical and tend to believe the worst. Until digital image processing is as easily accepted in court as are traditional photographs, it is our job to make it easier to accept such processing.

Strategies that help to ensure admissibility include, but are not limited to:

- Written standard operating procedures (SOPs) must be in place, which spell out what is and is not permissible. (Following standard guidelines, such as those provided by SWGIT, can also help to ensure that the procedures used are consistent from one agency to another.) Then, all operators of digital image processing hardware and software must adhere to the SOPs.
- Those with access to this technology must be adequately trained, and training records must be maintained.
- Limited access to this capability is recommended. This limits the chain of custody problems that may occur. Passwords must be issued to selected personnel, and restricted access is recommended.
- Some recommend that digital authentication software should be used to ensure images are authentic and uncompromised, while others believe it is sufficient to establish procedures that preserve the original and follow a "reliable" process to demonstrate the integrity of the image.
- Original, tamperproof images should be archived to a secure storage medium such as CDs or DVDs. Only copies can be processed and then offered in court. The original image is considered the equivalent of the film negative, which should always be secure and as originally captured.

- A detailed enhancement history must be maintained for each step in the enhancement process, which includes what tool or function was used together with the settings and parameters used. If a challenge in court is directed at a subsequent image that was digitally processed, a new copy of the original, authenticated image can be produced, and the imaging process can be performed again following the enhancement history to prove that the subsequently processed image was, indeed, derived from the original, not just a new image substituted somewhere in the process.

When all is said and done, the reliability of the imaging process; the digital image; and the integrity, training, and experience of the technician doing the imaging process are crucial elements regarding the admissibility of enhanced images when the enhancements are done with a computer. Under existing rules of evidence, the main requirements for admissibility of a photograph (whether digital or film) into evidence are relevance and authentication.

The integrity of these images is assured to some degree by the chain of custody, but the most important requirement is the ability to verify that the image is genuine and valid. In most cases, existing rules of evidence are applied to photographs that are admitted as evidence. In some cases, the technician must be prepared to testify that the images are accurate, reliable, and correct.

DIGITAL FORENSICS IS LIKE THE WILD WEST

> If digital evidence is important enough to convict a person, shouldn't the evidence be regulated in a manner similar to DNA? … Digital forensic evidence must be legally defensible to ensure that nothing in the original evidence was altered and that no data was added to or deleted from the original.[8]

Even though most of us have become more digitally conscious because of the plethora of digital devices, including digital cameras and smartphones with digital cameras, many law enforcement agencies still have a difficult time managing digital evidence. Many law enforcement organizations argue that digital imaging involves expensive, rapidly changing technology both for capture and storage. They cite concerns about system upgrades/technology replacement and concerns about reliable, long-term data storage. As a result, they use digital point-and-shoot cameras, which present significant limitations in the field. For example, these cameras do not perform well except when used on a bright, sunny day.

Law enforcement agencies are faced not only with a growing number of digital images from different sources, they are also being confronted with excessively large volumes of data from body-worn cameras and in-car (dash-mounted) video cameras. Disappointingly, the law enforcement community has become more reactionary and proactive. Issues typically are ignored or go unnoticed until they become a crisis. Predictably, these issues include developing guidelines and protocols such as how memory cards are handled and how images are downloaded and stored. What I find that is unbelievable today is that a vast number of agencies do not have an SOP (standard operating procedure), nor do they have standards for training, processing of digital evidence, and maintaining digital image integrity. Based on my experience, law enforcement agencies typically have officers download their images to a CD, and then the CD is put into the evidence room. More often than not, the officers do not verify whether or not the disk burning was successful before they delete the image files on their memory cards.

RULE OF THUMB 10.8

A majority of digital cameras used by law enforcement officers in the field do not have the correct date and time settings, which can be problematic. In addition, the majority of law enforcement officers are not aware that the act of rotating an image to view it after the image is downloaded to a computer will cause the image to be identified as a "modified" image.

Alternatively, a number of law enforcement agencies require evidentiary images to be stored on a server where detectives or other investigators have access to the images so that they can create copies of the files and make folders with those additional copies, etc. The problem then becomes one of accountability: how are links maintained from the original file to one or more copies in multiple folders — on multiple servers — on multiple hard drives — on multiple personal computers or laptops? Not only does accountability become a significant issue, but data storage becomes a crucial issue, as does locating the appropriate images at time of discovery.

[8]Michael Kassner, "Digital Forensics resembles the Wild West when it comes to regulation," TechRepublic, August 14, 2015 (see also: Bowers, Mike. "Digital 'forensic science' has blossomed by regulations and firm protocols are lacking," August 17, 2015. FORENSICS in FOCUS @ CSID-DDS | News and Trends).

In 2013, a sample survey of police departments revealed that approximately 75% of the agencies that responded did not use body-worn cameras.[9] That number or law enforcement agencies using body-worn cameras and dash-mounted cameras has increased significantly today. And now the issue of digital data storage is on the forefront of everyone's minds. How do you store that much data for an extended period of time? How do you back it up? How long does it need to be stored? How do you archive that much data? If the volume of data can not be managed by the local IT infrastructure, can the data be stored in the "Cloud"? How does storing data in the Cloud affect chain of custody issues? And the list of questions goes on and on.

The demand for improved and ever-expanding data infrastructures is on the rise as more and more law enforcement agencies want to implement a paperless environment. Some of the reasons for this switch are that paperless solutions:

- Are more affordable.
- Provide instant gratification.
- Allow easier information sharing.

WARNING: Careful planning, reason, and acceptable protocols must be considered when implementing a paperless solution. Law enforcement agencies as well as attorney's offices often rely on the creation and use of PDF "documents" as the foundation of their paperless solution. Using the default "standard quality" settings significantly degrade image quality and reliability. More specifically, images with a resolution greater than 225 ppi are downsampled to only 150 ppi, and the downsampled images are then compressed using standard jpg compression with only medium image quality (see Fig. 10.21). Even to maintain sufficient image quality for "viewable" images (images that may be used only for demonstrative or illustrative purposes), the default adobe PDF settings must be changed to "high-quality print." Therefore, unless the creator of the PDF document knows what he or she is doing, images embedded in PDF documents will *not* be suitable for analysis and comparison, or even for a review. In addition, the person(s) who receive the PDF will often print the document, and in many cases, the print settings will result in calibration issues, and 1:1 images will no longer be 1:1 images.

RULE OF THUMB 10.9

Using PDF creation Default Settings: "Standard," images with a resolution greater than 225 pixels per inch (ppi) are downsampled to only 150 ppi, and the downsampled images are then compressed using standard jpg compression with only medium image quality, rendering images in the PDF file unusable.

The concerns about—and headaches from—image storage, access, retention, and retrieval are growing rapidly and plague even the smallest law enforcement agency. The foundation for many of these concerns, frustrations and headaches is that image storage and management are the least standardized components in the world of digital imaging.

On the other hand, more and more law enforcement IT departments are discouraging the use of high-resolution images, stating that "JPG images provide sufficient data" for forensic analysis and comparison. While IT departments are grappling with data storage issues, most crime scene technicians and detectives are enjoying (and benefiting from) taking more pictures at the crime scene.

Questions that must be addressed for a successful digital imaging program include the following:

- Where are the images to be stored?
- How (in what format) are the images to be captured?
- Who downloads the images?
- How do you account for multiple cameras being used at the same crime scene? (More specifically, if two or more detectives are using a digital camera at the crime scene and both detectives reset their digital cameras to start with the number 1, how do you ensure that you can account for multiple image files with the same file name and how do you track which images were taken by which detective or photographer?)
- Who has access to the images (chain of custody also commonly referred to as the image integrity), both before and after the images are downloaded from the camera to the computer?
- How do you authenticate original images?
- How do you track and maintain the relationship between the original image and subsequent enhancements of that image?

[9]Office of Justice Programs, National Institute of Justice. "Research on Body-Worn Cameras and Law Enforcement" (http://www.nij.gov/topics/law-enforcement/technology/pages/body-worn-cameras.aspx).

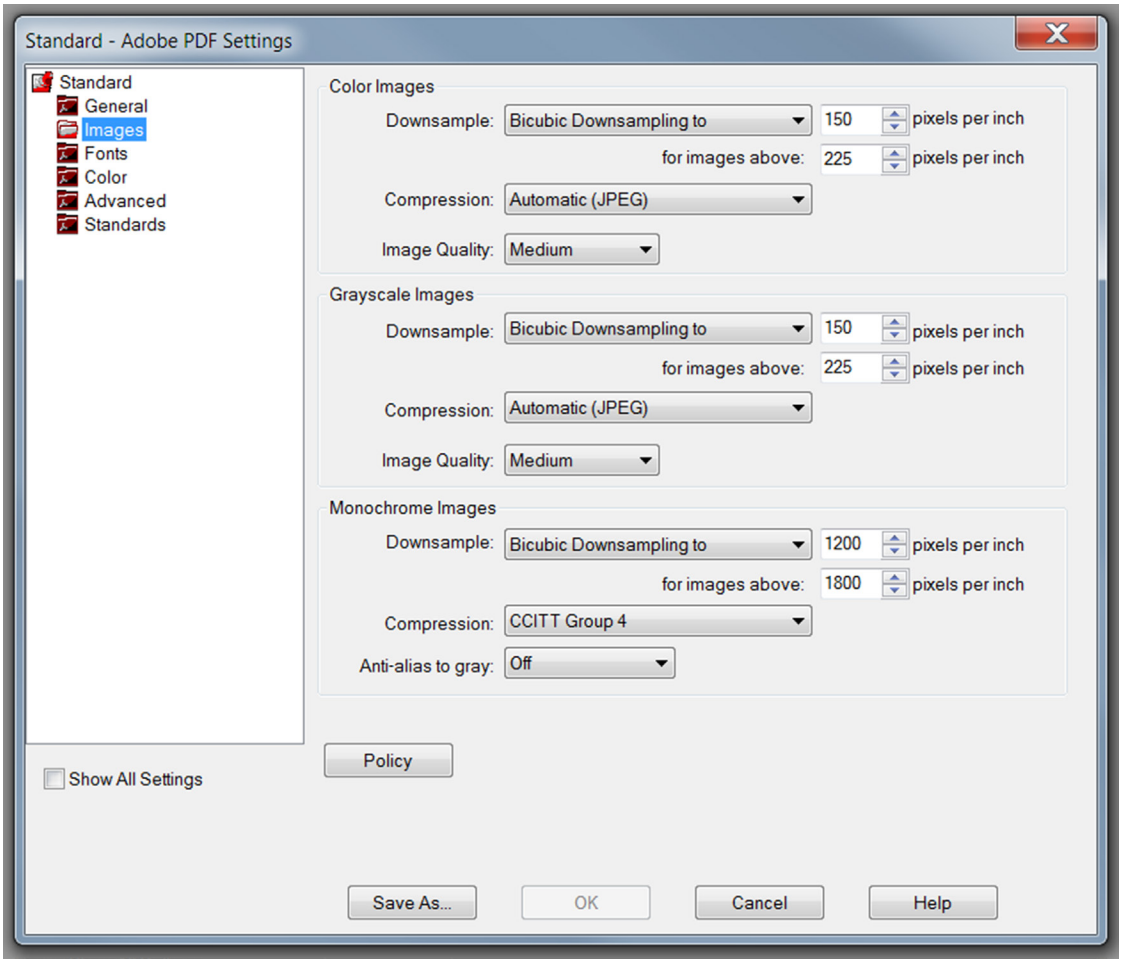


FIGURE 10.21
Using PDF creation Default Settings: "Standard," images with a resolution greater than 225 pixels per inch (ppi) are downsampled to only 150 ppi, and the downsampled images are then compressed using standard jpg compression with only medium image quality.

- How do you account for all images (originals and enhanced copies) for a single case? (Moreover, digital images can come from multiple departments within a single agency. They can come from evidence, crime scene unit, toxicology, serology, firearms, etc. When preparing for court, the agency must know what images exist in each of these departments to comply with discovery requirements. Finding and retrieving images from a vast number of departments can be a real problem for these agencies.)

It is also recommended that a minimum of two independent copies of all digital image files be maintained regardless of what image format is used. One of these copies should be stored offsite in a different location to guard against catastrophic events such as fire, tornados, earthquakes and floods. The second can be stored in the property room or in the computer room as specified by policy and procedure.

If images are being copied to CDs or DVDs, a procedure must be put in place to ensure that the images were written successfully to the CD or DVD properly before deleting the files from the camera, the camera media, or the local hard drive where the images were downloaded. The content of the newly created CDs or DVDs can be verified by opening one or more images on the disk after the images have been burned to the disk.

It is also recommended that media be "refreshed" every 5 years if CDs or DVDs are used for permanent storage. While this argument has come under fire because of the time and cost to perform this function, it is recommended that media be upgraded when new technologies become available to ensure continued availability and access to critical data. For more information on archiving digital images to CD or DVD, please refer to Section 15 of the SWGIT Guidelines, entitled *Best Practices for Archiving Digital and Multimedia Evidence (DME) in the Criminal Justice System*.

One of the "popular" concepts in some IT circles is to get away from archiving data and storing information indefinitely on the server. In concept, this may not be a bad idea, but the concept of backups is still a mandatory issue.

Some agencies are also using dual writing servers, so that as soon as data is written to the primary server, the exact same data is written to the secondary (backup) server. Then, if the primary server goes down, the secondary server automatically takes over and no data is lost and the agency does not have to stop its processes.

In these instances, it is imperative that a backup still be made and stored for later data retrieval. Why? Imagine having in image file that was saved on the server, and someone who has access to the server intentionally or unintentionally deleted the folder containing that file. Further, the deletion is not discovered for a couple of weeks. In a dual server environment, the image would have been deleted from the second server at or about the exact moment when the image was deleted from the primary server; there would no longer be a record of that image ever having existed. The only way to recover from a mistake like that is if there is a backup that still contains the now-deleted folder/image file.

The goal of implementing a successful digital imaging program can be achieved only through appropriate planning, training, and management. We have at our disposal the latest and greatest digital imaging technologies available. Not only can we reach for the stars, but now we can even see the stars more clearly than ever thanks to the wonderful world of digital imaging technologies.

SUMMARY

The acceptance of digital imaging has advanced significantly over the past three decades. Digital technologies touch our lives in many different ways every single day. Digital camera technologies have gone from costly low-resolution cameras to inexpensive high-resolution cameras. A majority of people now have 8-, 13-, 16-, or higher megapixel digital camera on their cell phones. Some cell phones include a digital image and/or digital video upload options for Facebook, YouTube, Instagram, etc. And some first responders are also taking pictures of the crime scene with their digital cameras. (That is a whole "other" issue/nightmare!)

And of course, there is the general public that is snapping pictures and videos of crime scenes and police interaction.

In a featured post in 2014 "The Data Explosion in 2014 Minute by Minute—Infographic," Susan Gunelius stated that five Exabyte's of content were created between the birth of the world and 2003. In 2013, five Exabyte's of content were created *every* day. The report also states that:

> … Google processes 20 petabytes of information per day. Using the same comparison from the Cost of Content Clutter infographic, think of it this way—all of the written works of mankind created since the beginning of recorded history in all languages equals 50 petabytes of information.

(And we all know that everything on the internet is 100% accurate and reliable … he says sarcastically.) Pictures and videos on the internet do not always tell the truth, and in fact are frequently manipulated.

However, the widespread use of digital cameras for crime scene investigation to photograph evidence such as latent prints, footwear impressions, and blood spatter continues to expand both in use and in acceptance in courtrooms across the country. Some defense attorneys have made the argument that digital imaging technologies provide judges and jurors visual access to things they would otherwise not be able to see, such as fingerprints on a piece of paper or a bite mark left on a victim's body, etc., and/or that these images can create bias or be prejudicial in the courtroom.

In 1979, the Connecticut State Supreme Court was the first court to adopt ground rules for the admissibility of computer-enhanced evidence to safeguard the right of defendants to challenge its reliability in accordance with Federal Rules of Evidence 901. In its 1979 ruling in *American Oil Co. v. Valenti*, 179 Conn. 349, 359, 426 A.2 d 305, 310 (1979), the court stated that there must be "… testimony by a person with some degree of computer expertise, who has sufficient knowledge to be examined and cross-examined about the functioning of a computer." It further stated that evidence presented using state-of-the-art computer technology must be accompanied by an expert's explanation of how the process works, and must allow for cross-examination on whether the evidence was in any way manipulated or altered. The court also adopted the guidelines set forth in Federal Rules of Evidence 901.

In a 2004 case, *State of Connecticut v. Alfred Swinton*, No. 16548 (Conn. May 11, 2004), the Connecticut Supreme Court reiterated the rule that there must be "testimony by a person with some degree of computer expertise, who has sufficient knowledge to be examined and cross-examined about the functioning of the computer" but also took the opportunity to clarify its 1979 position on the guidelines set forth in Federal Rules of Evidence 901. While these standards

have become case law and precedence, there is still a debate about what these standards mean. The standards in Federal Rules of Evidence 901, now commonly referred to as the "Swinton Six," are as follows:

1. The computer equipment is accepted in the field as standard and competent and was in good working order;
2. Qualified computer operators were employed;
3. Proper procedures were followed in connection with the input and output of information;
4. A reliable software program was utilized;
5. The equipment was programmed and operated correctly; and
6. The exhibit is properly identified as the output in question.

The court also stated that these six standards should be used as nonexclusive guidelines, and also implied that these standards may be relaxed once the processes of generating computer-based evidence become more accepted with consistent use.

In addition to complying with these standards, follow established standards and guidelines to preserve and protect the integrity of digital images as well as ensure their reliability.

It is crucial to understand the elements of digital imaging technology to ensure its successful use both in and out of the courtroom. Unfortunately, far too many people do not understand the impact of resolution on image quality because resolution varies from camera to monitor to printer. So you might say, "It is all about resolution," but then again, it is not just understanding resolution because digital imaging is more than just a bunch of pixels; it is how you visualize and interpret the image as well as how you deal with bias, uncertainty, image authentication and integrity.

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CHAPTER 11

Digital Image Processing of Evidentiary Photography

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Expert Witness
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Manipulation
Resampling
Requirements
Standard Operating Procedure (SOP)

Learning Objectives

On completion of this chapter, you will be able to

1. Explain the potential legal challenges concerning the use of image-editing technologies on forensic digital images.
2. Describe how the History Log is enabled and explain how the History Log can be accessed for a digital image processed with Adobe Photoshop.

Crime Scene Photography. http://dx.doi.org/10.1016/B978-0-12-802764-6.00011-8
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3. Describe the basic steps for digital image processing and identify the order in which those steps should be performed.
4. Define the legal principles that must be followed to ensure that digitally processed images may be accepted in court.
5. Explain what happens to images that are rotated at any degree other than in 90-degree increments as well as describe the effects on image processing.
6. Describe the primary methods used to remove multicolored backgrounds in Adobe Photoshop for forensic digital image processing.
7. Describe the techniques used to adjust tonal range when processing forensic evidentiary digital images as well as the pros and cons of each technique.
8. Identify the differences between digital images captured with a digital camera and a flatbed scanner and the impact these differences have on digital image processing.
9. Describe the primary image quality issues that must be considered when opening an RAW image file in Adobe Photoshop.

INTRODUCTION

One of the first milestones in the history of digital image processing occurred more than four decades ago. In the early 1970s, Jim Roberts, an officer in the San Diego Police Department, submitted a photograph of a fingerprint impression that was found in blood on bedding materials to the Jet Propulsions Laboratory (JPL) to be digitized in an effort to remove background noise. (The first attempt to use a Fourier transform filter to suppress the weave pattern in the image so that the ridge detail would be clearer, and the impression could be analyzed and compared.) Unfortunately, the results were not significant.

In the early to mid-1990s, some law enforcement agencies began using digital cameras. However, some law enforcement agencies were disappointed with the quality of digital images, even though they did not understand or distinguish among the quality of the captured image, how it was displayed, and in particular, how it was printed.

With digital photography, detectives or crime scene technicians could check recently taken digital images and then take additional pictures, if necessary. Also, these individuals did not have to carry around multiple rolls of different types of film. Once back at the department, they could make as many copies as they wanted without a loss of image quality or without loss of a significant amount of time. They could also share those images with other law enforcement agencies around the world, or with the local court, district attorney's office, state attorney's office, and so forth.

Moreover, soon would be gone the huge, expensive film developing equipment and the monstrous photo printers that cost literally hundreds of thousands of dollars. And along with that equipment went those messy chemicals that were not only expensive to buy, but were also costly to dispose of. And last but not least, all of the special photographic papers required for traditional film-based photography would be gone.

Since mid-2000s, companies like Nikon, Fuji, and Kodak started abandoning their film-camera business, including discontinuing their manufacturing of cameras, film, and photographic papers. Digital photography became the new norm for image capture, and businesses that had thrived for decades, like Kodak and Polaroid, even went bankrupt.

Replacing traditional photography were (1) digital cameras that cost only a couple of hundred dollars instead of several thousands of dollars; (2) film and flatbed scanners that cost less than 1000 dollars; and (3) printers that cost from less than a 100 dollars to a less than 2000 dollars.

The benefits of digital photography came at a price—a low price. But the lower cost of digital imaging was a great benefit for law enforcement agencies that were starting to feel the pain and suffering of declining budgets and the loss of funding (grant) opportunities. But the lower cost also lowered quality standards and expectations. Frequently was heard, "JPG is 'good enough' for crime scene photos … for forensics photos."

Even though many forensics experts, such as footwear and tire-tread examiners, firearms examiners, latent print examiners, and questioned document examiners, know and understand that output technology has lagged far behind capture technology, they still want to use a 1:1, life-size, printout of the digital image. There currently is no "low-cost" output solution that can produce the quality of photographs generated by the huge, expensive film processing devices available in some places such as Costco and Walgreens.

Today the majority of latent print examiners still use 1:1 copies generated by ink-jet, laser-jet, or dye-sublimation printers, which as we learned in the last chapter, use a cluster of dots to represent a single pixel; or, in the case of the dye-sublimation printer, a single pixel is produced on the dye sublimation through a process known as **Resampling**, a process where multiple pixel values are averaged using a mathematical equation to determine the single value to be used to represent the multiple pixel values.



FIGURE 11.1
Looking through a magnifying glass, latent print examiners use a ridge counters for analysis and comparison of ridge characteristics between the latent impression and the known exemplar.

To view the 1:1 image, the examiner must also use a magnifying glass (commonly referred to as a "loop") together with a "ridge counter" (also known as a "pick") to analyze and compare a latent impression to a known print as shown in Fig. 11.1.

This back-breaking, tedious process has also been simplified with improved digital technologies—high-resolution digital images being displayed on high-definition monitors with simplified tools for marking ridge events, for tracing ridges as well as marking areas of distortion, and so forth as shown in Fig. 11.2. In fact, a number of agencies in Canada and Europe *require* latent prints (also known as latent "marks") to be examined on-screen so the examiners can take advantage of the high-quality resolution when viewing the impression enlarged on the screen.

I am also a firm believer in analyzing and comparing impression evidence on screen, because I can enlarge both impressions and make each impression 12″ by 12″, or even larger. Using a 32-inch monitor, I still have nearly 8″ for an additional window on screen to make contemporaneous notes while viewing the two impressions displayed side by side.

This chapter is focused on helping to facilitate a greater understanding of **Best Practices** in the digital processing of forensic evidentiary photography using Adobe Photoshop because this program is too sophisticated and too widely used in the law enforcement community to be ignored. But more importantly, very few books focus on the application of the tools and techniques in a forensics environment. Almost every book you read about Adobe Photoshop describes how to manipulate digital images or how to use the tools creatively to produce new artwork. While some of these techniques may aid in the investigative process, forensic analysts must understand not only what tools and techniques may be used, but how to use them in a manner that will ensure their digital images are accepted in a court of law. Not only must the expert testify about the conclusions made using the digital images, but the expert must also testify about what procedures were used, as well as he/she must be able to explain why those procedures were used and the affect created within the image.

In accordance with Federal Rules of Evidence, Rule 702, "an **Expert Witness** is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:

RULE OF THUMB 11.1

An expert witness is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion.

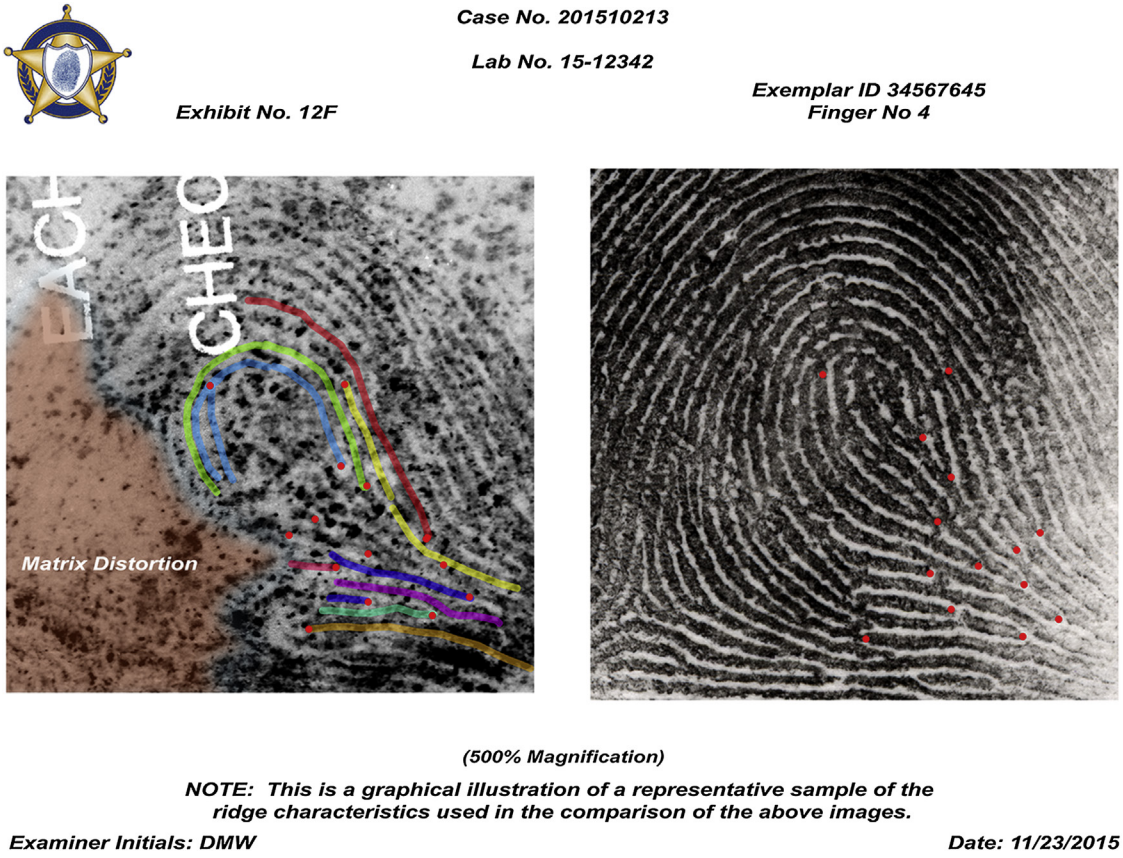


FIGURE 11.2
Automated tools are available to help simplify on-screen analysis and comparison. These tools provide the ability to mark minutiae, trace ridges, and mark areas with issues, such as distortion.

1. The expert's scientific, technical, or other specialized knowledge will help the trier of fact to *understand the evidence* or to determine a fact in issue;
2. The testimony is based on *sufficient facts or data*;
3. The testimony is the *product of reliable principles and methods*; and
4. The expert has *reliably applied the principles and methods* to the facts of the case." (emphasis added)

STANDARD OPERATING PROCEDURE

Frequently, many latent print images must be **Calibrated** and processed so that the impression can be viewed more clearly before the ridge detail can be analyzed and compared. In the past, photographic images of evidence were processed using traditional darkroom techniques that have been used for more than 100 years. The difference now is that we have high-resolution digital cameras, powerful computer technologies, and highly developed, sophisticated image-editing applications such as Adobe Photoshop that make it possible for literally anyone to manipulate digital images. Unfortunately, it is also possible to use digital imaging technologies to mislead, misrepresent, and confuse anyone looking at a digital image.

In October 2007, the police in London, England, were accused of manipulating a photo of Jean Charles de Menezes so that his picture could be compared to a photo of one of the alleged plotters of the July 21 bombings in London. Forensics consultant Michael George told the court that the police composite picture appeared to have "greater definition" than the two images used to create the composite. When asked whether there had been any **Manipulation** of the primary features of the face, Mr. George replied, "I don't believe there has been any ... but making the image brighter has changed the image." When the jury went into deliberation on the case in March 2008, the judge told the jury that a "serious allegation has been made that a picture has been manipulated so as to mislead."

Manipulation has been commonly accepted to mean "the altering of an image using software tools to produce an artificial image and create new meaning." It has also been alleged that Adobe Photoshop produces results that are so high in quality that it is almost impossible to tell if the photo is real or if it has been manipulated.

But how could making an image brighter make it misleading? Could it be an issue of perception? Or could it be one of not understanding the technologies properly and not being able to explain the processes adequately in the courtroom? One of the concerns raised in the *State of Connecticut v. Alfred Swinton* case dealt with similar issues: the individual's opinion based on a perception drawn from the digital images as well as the lack of knowledge about the technology and the process.

Over the years, image **Enhancement** has come to mean different things to different people. To a divorced wife, it could mean that she "photoshopped" her pictures to remove her ex-husband from the scene (and her picture memories) both figuratively and literally. To the photojournalist, it means "photoshopping" a digital image to persuade or invoke a strong emotion about a story (that could be about an event, place, or person). To the marketing or sales director, "photoshopping" means "creating" an image or perception that invokes an action to buy something or to do something. (Did I just say "creating"? Oops! Yes, I did.)

Note: When testifying in court, I personally do not like to use the term "enhancement" because a number of negative connotations have become associated with this term over the years. I prefer to use the term "process" when describing the procedures (tools and techniques) that were employed in the "development" of the image. Historically, we have stated that film had to be processed to develop the negatives for printing; so until the film was processed, the images on the negatives were not visible. Similarly, when talking about developing a print on a piece of paper, a chemical process (such as ninhydrin or indanedione) was used to develop the impression so that the impression is visible. (One of the definitions in the Merriam-Webster Dictionary for "enhance" is to "intensify, increase, or further improve the quality, value, or extent of," but it also means to "change," as I was reminded by a particular defense attorney.) Then, once the image has been processed and the print was developed, I used a series of steps (tools and techniques) for which the specific settings and parameters are documented so that the detail within the image could be viewed more precisely, a conclusion could be made more accurately, and the weight of the evidence was based on the reliability of the evidence.

To the forensic analyst, it means "processing" digital images of a wide variety of evidentiary items, such as latent fingerprints or palm prints, footwear impressions, tire marks, tool marks, questioned documents, bloodstains, and gunshot residue, for analysis, comparison, and evaluation. The forensics analyst also faces unique challenges that are not involved in any other digital imaging scenario. In some instances, the evidence can be seen upon physical examination or with basic capture-and-recovery techniques. In many situations, however, the forensic analyst must use special processing techniques to see the evidence. For example, a forensics analyst may have to use techniques such as ninhydrin, indanedione, DFO, or zinc chloride on porous surfaces such as money or paper; or cyanoacrylate fuming on nonporous surfaces such as plastic, glass, and metal. Some processes, such as indanedione, Ardrox, Basic Yellow, Rhodamine 6G, and Coomassie Blue, require special light sources to view and digitally capture the images. These images also require special image-processing techniques to make the images visible to the human eye.

The challenge for forensic digital evidentiary photography is that every digital image must be captured, stored, processed, and managed in a manner to ensure that it will be admissible in the courtroom. To meet this challenge, law enforcement agencies are required to have a **Standard Operating Procedure (SOP)** that describes the digital imaging process from the time the evidence is photographed at the scene until the processed digital image is presented in court. For example, the courts generally have held that the original, unedited image file must be available and that original image file can be authenticated; and if image processing was involved, the changes must be made to a copy of the original and that each step of the process is documented so that the procedure could be repeated, if necessary.

RULE OF THUMB 11.2

Law enforcement agencies are required to have a standard operating procedure (SOP) that describes the digital imaging process from the time the evidence is photographed at the scene until the processed digital image is presented in court.

There is currently no case law in the United States, Canada, or Europe that addresses the processing of digital images from a specific camera or from a specific photo-editing software application. The Scientific Working Group on Imaging Technology (SWGIT), however, has developed a number of **Guidelines** for the forensic imaging practitioner that provide a foundation for the acceptance and adoption of consistent standards, practices, and methodologies. Although invaluable, these guidelines do not provide specific **Requirements** for hardware or software, nor do they provide specific requirements for the capture and processing of digital images. Given the sheer volume of hardware and software applications, such a task would be unwieldy.

Just like there is a plethora of digital cameras available, there is a wide range of photo-editing software applications, such as Adobe Photoshop, Google's Picasa, Photoscape, Picnik, Corel Paint Shop Pro, GIMP, Serif PhotoPlus, Ulead PhotoImage, ACDSee Photo Editor, Roxio Photoshow, Media Cybernetics Image Pro Plus, and the list goes on and on. Some of these software packages can be downloaded for free, whereas others can cost hundreds or thousands of dollars.

Some of the features and functions that must be provided by these applications include the ability to resize images, adjust brightness and contrast, adjust hue and saturation, adjust white balance, make backlight corrections, add text, crop, remove backgrounds and eliminate noise, sharpen the image, and even search for similar faces on the Internet. Some applications even provide the ability to do batch processing, such as changing file names for a batch of images or processing a batch of images using the same color adjustment or the same brightness and contrast settings simultaneously. The protocols (procedures) for performing these tasks should be outlined in an SOP.

In addition to defining procedures for image processing, SOPs should include a number of topics including, but not limited to: (The following list of topics is provided as a sample of items that should be covered within a department's SOP. An entire book could be dedicated to creating an SOP if we were to focus on a complete list of topics that may or should be included within the department's SOP.)

- By whom and how is the crime scene to be photographed?
- By whom and how is the evidence discovered at the crime scene to be photographed?
- What special equipment and other considerations, if any, are required when photographing evidentiary items at the crime scene, such as footwear, tire tread, blood spatter, and latent prints (such as using a digital single-lens reflex (SLR) camera with interchangeable lenses; a scale must be included in every overall digital image and every close-up image of every piece of evidence photographed at the crime scene; and so on).
- How are digital image files of the crime scene and the evidence collected to be transported back to the department?
- How are digital image files of the crime scene and the evidence collected to be downloaded from camera(s)/media?
- How and where are the original digital image files/digital evidence to be stored?
- By whom and where are copies of the digital image files to be made after the images have been downloaded? (As stated in the previous chapter, the Best Evidence Rule states that "[i]f data are stored in a computer or similar device, any printout or other output readable by sight, shown to reflect the data accurately is an '*original*'." Further, processing of a digital image, if any, must be performed on a *copy* (ie, exact bit-for-bit duplicate) of the original image.)
- How are original and the enhanced digital image files authenticated to prove their authenticity and integrity?
- When/where are the original image files backed up?
- Who has access to the original files; to the copies of the original files?
- Who is responsible for processing the physical evidence, if required?
- When must digital images be captured to preserve the results of individual processing steps, such as preserving ridge detail that was developed on a sheet of paper after it was processed with ninhydrin but before it was processed with DFO?
- How is a step-by-step processing history to be created and maintained for each Category 2 image (ie, images that are used for scientific analysis), including sufficient detail (settings and parameters) to allow another person with comparable skills, comparable training, and comparable expertise to create a comparable result? (A pixel-by-pixel recreation is *not* required!)

It is highly recommended that multiple photographs be taken of each piece of evidence being processed. For example, take a complete, overall photograph of a beverage container (such as a can or bottle bearing possible ridge detail) as well as a close-up of the individual impression(s). In addition to helping identify which hand may have deposited the ridge detail, the overall image could help determine simultaneity whereas digital images of individual impressions can only be considered on their own.

RULE OF THUMB 11.3

It is highly recommended that multiple photographs be taken of each piece of evidence being processed.

In addition, if it can be determined that the latent impression could only have been made by the left middle finger, the speed and accuracy with which a manual comparison could be made against submitted exemplars, if any, could be improved considerably. Similarly, if the impression were to be searched in an Automated Fingerprint Identification System (AFIS), and the portion of the database to be searched were limited to a specific finger number and pattern type, both the speed and accuracy of the automated search and comparison would be improved considerably.

Best Practices and Guidelines

In chapter "Digital Imaging Technologies," we provided an insight into what digital imaging is and what can be done with this technology, what is acceptable, and how it can be presented so that it is accepted in a court of law. One of the primary principles involving what can be done with this technology is to capture the best image possible with the highest-resolution possible. The supporting tenet for that principle is to fill the frame with the subject matter only (do not include any excess area in the image).

As shown in Fig. 11.3, the same ISO Resolution Chart for Electronic Still Cameras was captured digitally using the same digital SLR camera (Nikon D800) with the same exposure settings (shutter speed (1/60 s), f-stop (f/22), ISO setting (100), and same metering (Centerweighted-Average)). There were only two things that changed: the lens, and the distance from the lens to the object. To determine the distance from distance from the lens to the object, the resolution of the imaging sensor was divided by 300 to determine the size of the area that could be viewed through each lens where the image resolution of the captured area would be 300 pixel per inch (PPI). The image appearing on the left side in Fig. 11.3 was captured using a 60 mm macro f/2.8 lens; the middle image was captured using an 18.0–55.0 mm f/3.5–5.6 lens; and the image on the right was captured using a 105.0 mm f/2.8 lens. The image captured using the 60 mm macro lens has the clearest detail, while the 18.0–55.0 lens also showed effects of the curved lens; and the image from the 105 mm lens was more blurry. Hence there is indeed more to capturing an image than just filling the frame; you must use the appropriate lens, and so on, when filling the frame.

Further, if the digital image is to be used for analysis and comparison (such as a latent fingerprint or palm print, footwear impression, tire mark, tool mark, questioned document, bloodstain, firearms comparison, and gunshot residue), a scale *must* be included in the image. While a scale is not technically required in a digital image that is scanned, many law enforcement agencies have made it a policy to include a scale in all digital images to ensure consistency as well as to have the ability to prove that the image can be produced (printed) accurately and reliably at life-size (1:1) scale.

RULE OF THUMB 11.4

If a digital image is to be used for analysis and comparison (such as a latent fingerprint or palm print, footwear impression, tire mark, tool mark, questioned document, bloodstain, firearms comparison, and gunshot residue), a scale must be included in the image.



FIGURE 11.3
Using the wrong lens and failing to keep the object as close to the image possible can degrade the quality of the digital image.

When capturing an image digitally—whether using a digital camera or a flatbed scanner—it is imperative that the image be captured in color. This is true regardless of whether or not the item being scanned is a black powder lift card or a ninhydrin print on a check.

RULE OF THUMB 11.5

When capturing an image digitally—whether using a digital camera or a flatbed scanner—it is imperative that the image be captured in color.

Once the digital image has been captured successfully, there are a number of variables that affect not only whether or not the digital image can be processed, but also how the image can be processed for better clarity. For example, if a latent print was developed on a plastic baggie that had been processed with cyanoacrylate (superglue fuming); this image may only need to be inverted to convert the white ridge detail to black ridges. Similarly, you may have photographed a gray or white power lift that also needs to be inverted to convert the white ridge detail to black ridges.

Or perhaps you acquired a latent print processed with ninhydrin that appeared on a check with a solid blue, pink, or a multicolored printed security background consisting of lines or dots. Or perhaps a print was developed using ninhydrin on a brown, rough-textured paper bag or a yellow smooth-surface paper bag.

All these scenarios are very possible. The bottom line is that you can acquire images from an unlimited number of surfaces, including skin, as well as acquire images that have been processed using any number of powders, chemical processes, dyes, fluorescent powders, and dye stains, and more.

You also have an arsenal of light sources to aid in the visualization and capture of latent prints, body fluids, gunshot residue, and so on. Simply stated, all images—even images processed using the same development process (such as ninhydrin) on the same type of surface (such as paper) with the same type of light source—cannot be processed using the exact same technique. Therefore, it is impossible to provide a scenario in which you will always use the exact same process.

General Guidelines

SWGIT has defined two categories of digital images that are commonly used in the criminal justice system throughout the United States: Category 1 and Category 2 images.

- Category 1 images are those images that are considered to be documentation and are not used for analysis.
- Category 2 images, on the other hand, are considered evidentiary in nature and are typically used for analysis and comparison.

RULE OF THUMB 11.6

The easiest way to distinguish between Category 1 and Category 2 images is that Category 1 images are used for demonstrative or illustrative purposes. Category 2 images, on the other hand, are used for "scientific analysis" and to reach a conclusion.

SWGIT also has defined different processing guidelines for these two categories.

Category 1 images may be acquired using a JPG file format. In addition, a detailed history is not required for Category 1 images. In lieu of a detailed image-processing history, the agency can specify precisely what image-editing functions may be used to enhance Category 1 images in its SOP.

In addition, most digital cameras today provide three image quality settings when saving JPG images. It should be remembered that the higher the image quality, the larger the file size; the lower the image quality, the smaller the file size. The following descriptions are provided for a better understanding of the three basic JPG formats:

- Low image quality (also known as "Small" on some digital cameras): Highest compression/lowest image quality (this format is good for viewing digital images on the Internet, such as on web pages and e-mailing, but it is not good for printing unless printed as a small image, such as a wallet size image or thumbnail image)

- Medium image quality: Medium compression/average image quality (good for printing 3 × 5 prints and perhaps 5 × 7 prints, and can be e-mailed easily; generally too large for use on web pages or social media)
- High image quality (also known as "Fine" on some digital cameras): Least compression/best JPG image quality (good for printing 8 × 10 prints and can still be e-mailed relatively easily)

When defining acceptable image quality standards within their SOPs, law enforcement agencies should always establish a policy of using a JPG format with the least compression for the best image quality. It should also be remembered that the original pixel values are discarded when the image data is written to the media inside the camera, and once the original pixel values are lost they can never be recovered exactly as captured.

There are, however, times when a JPG file format is not acceptable for use with Category 1 images beyond the initial capture and storage of the original image. For instance, it may be necessary to process an image to reveal details hidden in the shadows, annotate the image, and so forth. Once a JPG file is decompressed and then processed, it is important to save the image in a standard TIF format so that the image is not recompressed again and additional degradation occurs within the image. Also, annotations should never be made directly on the original image; a blank layer should be added to the image and the annotations made on that layer so that it can be turned on or off as necessary, and the annotated image *must* be saved as a TIF file because in addition to pixel values being compressed when image data is saved as a JPG file, all layers are flattened and any annotation(s) made will overwrite the underlying pixel values, and will then be comingled and compressed with the image pixel values. Once the destruction has been done, it cannot be undone.

In addition to defining image quality standards, the SOP must also define what tools and techniques may be used with Category 1 (documentation) digital images. Since the department's SOP is discoverable along with all digital image files associated with the particular case, keep it simple!

Typically, these basic techniques are used to improve the overall appearance of the image:

- Adjusting brightness and contrast
- Adjusting color balance
- Adjusting hue and saturation
- Adjusting white balance
- Basic image sharpening or blurring
- Cropping
- Rotating

Category 2 images are another matter entirely. SWGIT recommends that Category 2 images be captured using a noncompressed file format such as RAW or TIF; however, as stated in chapter "Digital Imaging Technologies," SWGIT changed the "requirement" to capture images using a noncompressed file format to provide examiners more flexibility in accepting images where there is sufficient detail to make an identification. In addition, all Category 2 images must also have a detailed image-processing history in which each tool/techniques used must be documented because these functions can affect the results when used with advanced enhancement techniques on the same digital image.

Some of the more commonly accepted, advanced image-processing techniques include:

- Color and tonal range corrections
- Color channel selection and subtraction
- Fourier analysis (pattern identification and extraction)
- Advanced noise reduction (such as Dust and Scratches filter)
- Advanced image sharpening (such as Unsharp Mask and Smart Sharpen)

In addition to maintaining the sequence of the steps used during the imaging process, the settings and parameters must be documented for each step. The information must be sufficiently detailed so that a person with comparable skills, training, expertise, and experience could repeat the process and achieve a *comparable result*. There is no case law, guideline, or recommendation that requires that the imaging process must be reproduced with pixel-by-pixel accuracy, but the results should be a "reasonable likeness."

There are also some guidelines that are the same for both Category 1 and Category 2 digital images:

1. All original digital image files must be preserved in their original file format exactly as they came from the digital camera. At no time is it permissible to overwrite an original image file! For legal purposes, the "original" electronic file must be retained and, if requested, must be available for discovery and/or court.
2. Any processing performed on a digital image must be performed on a copy (duplicate) of the original. The parent–child relationship of the original image and the copy of that image must be maintained so that the images can be identified properly in accordance with Federal Rules of Evidence 901. Both the original and processed image must be authenticated to the extent that it can be demonstrated that the images are true, accurate, and reliable.
3. All digital images must be handled with the same care and control as physical evidence, and a chain of custody must be maintained for all digital images. (As stated in chapter: Digital Imaging Technologies," [i]n addition, ASCLD/LAB-International Supplemental Requirement 5.8.4.2 to ISO 17,025 states that digital photographs of non-recoverable latent impressions much be treated with the same care and control as the physical evidence itself.") Access to digital images stored on a workstation or server that is accessible by a number of individuals must be controlled. User rights and permissions must be controlled, which include but are not limited to privileges for viewing, printing, copying, exporting, archiving, and deleting. The chain of custody should also identify anyone who has accessed both the physical evidence and the digital image of that evidence and any related workflow.

In addition to defining the procedures that are to be used for digital image processing within an SOP, the procedures should also be consistent and should make sense as well. For instance, one law enforcement agency stated in its SOP that *[y]ou may not delete any digital image from a media card or digital camera. … All digital image files are to be preserved in their original format to ensure sequential integrity.* ... A couple of pages later, that same SOP states that *all digital image files are to be downloaded to the server* for daily backup, etc., and that after the files are downloaded, the *file names are to be changed to reflect the case number* ... for easy identification.

At first glance, this contradiction may not appear to be an issue. But this practice does not comply with SWGIT guidelines. Changing file names is not a practice that is generally accepted (or practiced) for digital images taken at a crime scene. In fact, several prosecutors and defense attorneys have questioned the practice of renaming files. While most "tech-savvy" individuals within the legal community have no problems with the idea of deleting an image on the camera, but they express concerns about renaming files, citing issues about human error, loss of timeline, and so on.

The basis for the guideline/recommendation of not deleting pictures goes back to the use of film when it was illogical to remove a frame in the middle of a strip of film. With digital cameras, it is technically possible (and technically feasible) to delete a digital image if it is out of focus or the camera settings (such as white balance, shutter speed, aperture setting, and exposure) are not correct, and so on. Of course, if the SOP allows for the deletion of digital images on the camera, there should be some guidelines established that define *when* it is acceptable or permissible to delete a digital image file.

The bottom line is that SOPs must be reviewed and evaluated carefully for obvious contradictions and mistakes, and that the policies and procedures make sense and are easy to follow. As the old saying goes, keep it simple and short. Try to define consistent procedures that work in all situations to avoid confusion and frustration, and do not be so elaborate that steps can be missed/skipped unintentionally.

For example, expecting a person taking pictures at a crime scene to change the file format settings on a digital camera back and forth from JPG to RAW between photographs most likely is not a reasonable expectation. There is a potential for human error, and a critical piece of evidence may be photographed using a compressed file format resulting in a digital image that is not be suitable for digital image processing.

IMAGE-PROCESSING GUIDELINES

With all of the image-processing software and tools that are available today, image processing is not rocket science! More than 40 years ago, digital image processing *was* rocket science. The National Aeronautics and Space Administration (NASA) first introduced digital image processing to repair degradation of image signals that were captured in space and sent back to earth.[1] The concept for digital image processing was developed by Dr. Robert Nathan in 1959 at

[1]Castleman, K.R.,1979. Digital Image Processing, Prentice-Hall, Englewood Cliffs, NJ, p. 389.

the JPL. But before the first images from space could be enhanced, the Video Film Converter had to be constructed to transform analog video signals into digital images, and it was not completed until 1963 for use with video images captured by the Ranger and Surveyor programs. But even then, digital image processing had to gain full acceptance, which did not occur until the Mariner Mars missions in 1969.

In 1968, research was had under a series of grants from the National Institutes of Health in the area of digital image processing to aid microscopy and medical diagnosis in the enhancement of X-rays. Unfortunately, the government canceled all fundamental research grants in the field by 1973, and as the old saying goes, "the rest is history." Digital image processing has gained widespread acceptance in literally every facet of life and discipline in science. It also impacts nearly every area of our daily lives as well, from enhancing signals that are displayed on televisions, computers, and so on; improving the quality of digital images captured using cell phones, digital cameras, so on and so forth. It is nearly impossible to think of an area in which digital image processing is not used.

While there are some basic guidelines for the image enhancement process, there are no specific requirements that dictate the order in which these processes should be used. The primary reason is that it is impossible to define every possible image enhancement scenario as well as every possible combination of tools that could be used for each scenario. But there is a suggested order that generally can be followed when processing digital images.

First, let us look at the steps most commonly used during digital image processing, and then we will go into more detail for each process.

The following steps are offered *only* as a recommended order and in no way are these steps intended or implied to be the required order of processing for the enhancement of all digital images.

The Order of Enhancements

(Doesn't it sound like there should be a ribbon and medal for this Order? I personally think there should a ceremony to honor those who have contributed in a noble way to the enhancement of digital images … but not to be confused with other Orders, like the Order of the Garter. Ok. I was just checking to see if you are really reading all of the information in this chapter.)

Before you get started with the enhancement process, there are few of things that you should consider.

1. Capture (photograph or scan) the evidence following the procedures described in the SOP. Be sure to capture overall images as well as close-ups of the evidence, and ensure that a scale is included in all images as described in Section 8, "General Guidelines for Capturing Latent Impressions Using a Digital Camera," Version 1.3 2010.06.11, and Section 9, "General Guidelines for Photographing Footwear and Tire Impressions," Version 1.0 2013.09.27.
2. Download the electronic files from the digital camera and authenticate the image files following the guidelines described in Section 13, "Best Practices for Maintaining the Integrity of Digital Images and Digital Video," Overview of SWGIT, and the Use of Imaging Technology in the Criminal Justice System, Version 1.0 2007.06.04.
3. Copy (duplicate) the original image file and authenticate the copied file following the guidelines described in Section 13, "Best Practices for Maintaining the Integrity of Digital Images and Digital Video," Overview of SWGIT, and the Use of Imaging Technology in the Criminal Justice System, Version 1.0 2007.06.04.
   Caution: At no time is it permissible to overwrite the original image file! For legal purposes, you must maintain the "original" electronic file so that it is available, if requested, for discovery and/or court. Any processing performed on the digital image must be performed on a copy of the original.

RULE OF THUMB 11.7

At no time is it permissible to overwrite the original image file! For legal purposes, you must maintain the "original" electronic file so that it is available, if requested, for discovery and/or court. Any processing performed on the digital image must be performed on a copy of the original.

4. If required, process the digital images following the procedures as defined. As defined in SWGIT Guidelines, Section 11, "Best Practices for Documenting Image Enhancement," version 1.3 2010.01.15, "[a]ccurate documentation is necessary to satisfy the legal requirements for introducing forensic images as evidence in a court of law and to allow other professionals to understand the enhancement and produce comparable results." Therefore, it is extremely important to document the processes and techniques used "when performing a variety of enhancement operations on still images, regardless of the tools and devices used." It is equally important to ensure that the agency's SOP includes instructions regarding the level of documentation that is appropriate/required.
   a. Calibrate (scale) the image for life-size output, including printing as well as exporting to an AFIS
   b. Evaluate color modes and channels, or it may be necessary to adjust color values within the image
      i. Review the following color modes (color channels) to remove one color value:
         - Image > Mode > RGB
         - Filter > Foray > Chromatic FFT
         - Image > Mode > CMYK
         - Image > Mode > **Lab Color** (Lightness channel, Channel a (green + red) or Channel b (green + blue))

         When using LAB color, it is necessary to adjust the levels in Channel A and Channel B to properly evaluate the information contained within those two channels.
      ii. If none of the color modes provide the desired results, then you may need to adjust individual color values to isolate the background. In other words, using one color channel may not be sufficient to eliminate all of the background color values that interfere with the visualization of the image. Therefore it may be necessary to adjust the color values so that a single color channel can remove the background. The following tools can be used to remove two or more color values as well as adjust the color values so that a color channel may be used to eliminate the background:
         - Image > Adjustments > Hue and Saturation (eliminates two or more color values; may be used in conjunction with **Calculations** to eliminate background noise)
         - Image > Adjustments > Color Balance (after adjusting color balance, it may be possible to suppress background noise and patterns using color modes and/or channels, calculations, so on and so forth)
         - Image > Adjustments > Black and White (available in Adobe Photoshop CS3 and later; may be used to suppress background and noise by increasing or decreasing specific color value(s))
         - Image > Adjustments > Variations (after adjusting color variations, it may be possible to suppress background noise and patterns using color modes and/or channels, Calculations, so on and so forth)
         - Image > Adjustments Photo Filter
         - Filter > Camera Raw Filter (available in Adobe Photoshop CC 2014 and later; provides the ability to adjust white balance as well as other hue, saturation, and brightness values to suppress background noise using a variety of color processing techniques)
      iii. In some instances, you may not be able to suppress the background using the tools described above, and it may be necessary to subtract background information using Image > Calculations. This process creates a multichannel image, and most often is used to eliminate backgrounds in chemically processed prints, such as ninhydrin processed prints on checks or money orders
   c. Convert active color channel to grayscale; after selecting the appropriate color channel (and removing the background noise, if required):
      Image > Mode > Grayscale
      If a continuous, consistent, and repetitive pattern can be identified within the image, a pattern removal filter, if available, should be used immediately after the image is converted to grayscale. (This must be done before adjusting tonal range and contrast to avoid raising the tonal range of the fingerprint, etc. to the same frequency as the obstructing pattern.)
   d. Adjust tonal range and contrast. There are a variety of options for adjusting tonal range and contrast, and you may use one or more of the following options together to achieve the desired result:
      i. Image > Adjustments > Levels (balance tonal range)
      ii. Image > Adjustments > Curves (extraordinary contrast)
      iii. Image > Apply Image (multiply, overlay, screen, etc.)
      iv. Image > Adjustments > Shadows/Highlights (balance tonal range and contrast)
      v. Image > Adjustments > Exposure (balance tonal range)
      vi. Burn and Dodge
      vii. Image > Adjustments > Brightness/Contrast

e. Once you have achieved the desired tonal range and contrast, you may want to perform a series of "filter" functions to eliminate hotspots (aka "noise") that may occur as a result of using an alternate light source with florescent/dye stained latent prints. Or, you may need to fine-tune the image to eliminate blurring caused by the digital photographic process using the following tools:
   i. Filter > Noise > Dust and Scratches (removes artifacts—using dissimilar pixel values—introduced through instrumentation, and so on)
   ii. Filter > Noise > Reduce Noise (removes random artifacts—based on edges—introduced through instrumentation, and so on)
   iii. Filter > Sharpen > Unsharp Mask (adjusts the contrast of edge detail and produces a lighter and darker contrast on each side of the edge, emphasizing the edge and creating the illusion of a sharper image)
   iv. Filter > Sharpen > Smart Sharpen (similar to Unsharp Mask, but provides significantly more control)
   v. Filter > Sharpen > Sharpen Edges (similar to Unsharp Mask, sharpens areas where significant color changes occur, but significantly less control than Unsharp Mask or Smart Sharpen)

f. After the image has been successfully processed, and no additional processing will be required, the image may be rotated. To avoid worsening the artifacts created by rotating an image, it is important to rotate the image once—and only once!

5. Save the image:
   a. Save the processed image as a copy—it is important to maintain the same naming convention to help identify the relationship between the original image and the processed copy of that original
   b. Save as TIF (no compression)
   Caution: Do *not* overwrite the original image!!! As stated earlier, the original image must be available if requested, for discovery and/or use in court.
   If the processed image is to be submitted to a local AFIS or to the FBI's NGI (Next Generation IAFIS) system, complete steps 6–10.
6. Make a duplicate copy of the processed image file—do not overwrite the previously processed image file when preparing the AFIS image!
7. Rotate the image so that the image has a vertical orientation (the axis of the image should correspond to the axis of the image in the AFIS).
8. Set the image resolution to correspond to the resolution for your AFIS (typically either 500 or 1000 PPI for latent prints).
9. Crop the image (typically the block size should be cropped to 1.5″ by 1.5″).
10. Save the AFIS Clip and transfer the electronic file directly to your local AFIS.
    To maintain the highest possible image quality for your AFIS submissions, do not print the AFIS clip and then scan the printed image. The electronic file will produce a clearer image, making minutiae extraction much easier as well as more accurate and reliable.

Enabling Photoshop's History Log

In accordance with SWGIT guidelines, a detailed history of the enhancement process must be maintained for every Category 2 image. Adobe Photoshop (versions CS and later) provides the ability to automatically record a detailed history of literally every mouse click made during the imaging process. The History Log not only records each process (settings and parameters) that is performed, but the log also documents if one or more steps are undone/redone as well as documents the number of steps that have been undone and then records any steps taken from that point forward.

RULE OF THUMB 11.8

In accordance with SWGIT guidelines, a detailed history of the enhancement process must be maintained for every Category 2 image.

By default, the History Log is disabled and must be enabled before the history is recorded for any image. To enable the History Log in Adobe Photoshop, do the following:

1. From the Edit menu, choose Preferences
2. The Preferences dialog box will appear
3. Click in the check box to the left of History Log; a green checkmark should appear in the box, as shown in Fig. 11.4
4. By default, the metadata option is selected, but confirm that this option is selected, as shown in Fig. 11.4
5. Then choose the option Detailed from the Edit Log Items drop-down list, as shown in Fig. 11.4

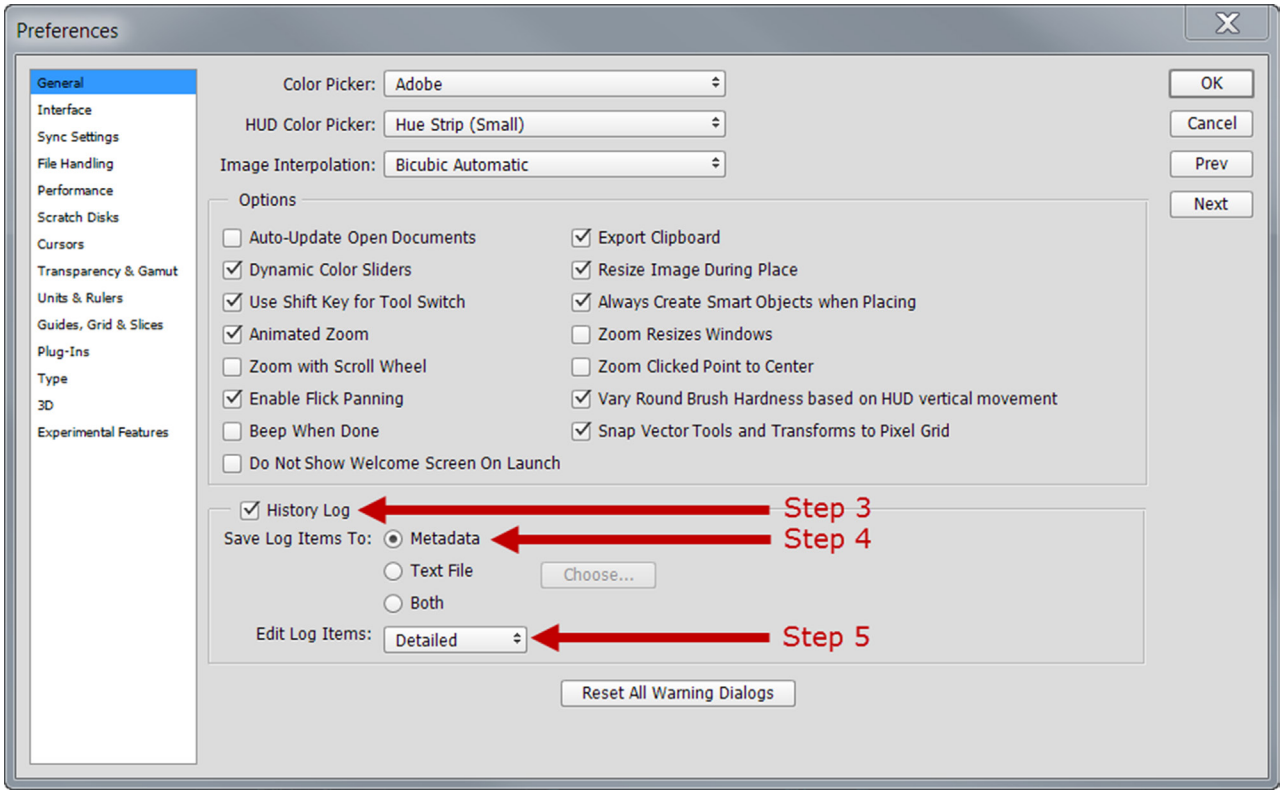


FIGURE 11.4
There are three settings that must be verified before starting any digital imaging process, especially when processing Category 2 images that are to be used for "scientific analysis."

The History Log function appears on the page for "General" preference options for Adobe Photoshop CC 2014 and earlier. For Adobe Photoshop CC 2015, the History Log has its own, dedicated page and is selected by clicking on the option History Log in the white narrow panel on the left side of the Preferences dialog box.

Viewing the History Log

The History Log can be viewed at any time during the enhancement process by going to the File menu, then choosing File Info, and clicking on the History tab in the File Info dialog box. (This is the same window where EXIF data can be viewed as well as the Camera RAW data for RAW files opened inside Adobe Photoshop.)

RULE OF THUMB 11.9

The History Log cannot be printed from any version of Adobe Photoshop; however, it can be copied and pasted into a text-editing application place like Microsoft Word and then printed.

1. From the File Menu, choose File Info …
2. When the file info dialog box opens as shown in Fig. 11.5:
   a. For Adobe Photoshop CS6 and earlier, locate the tab at the top of the window entitled "history."
   b. For Adobe Photoshop CC and later, the History is accessed by choosing the option Photoshop on the panel on the left side of the File Info dialog box.
3. When the history is displayed, move and place the cursor to the left of the very first letter of the first line, which is typically the number 2 (part of the date that appears on the first line of the history), and then click and release the left mouse button.
4. Scroll down to the bottom of the history, move and place the cursor to the right of the very last letter of the very last line.

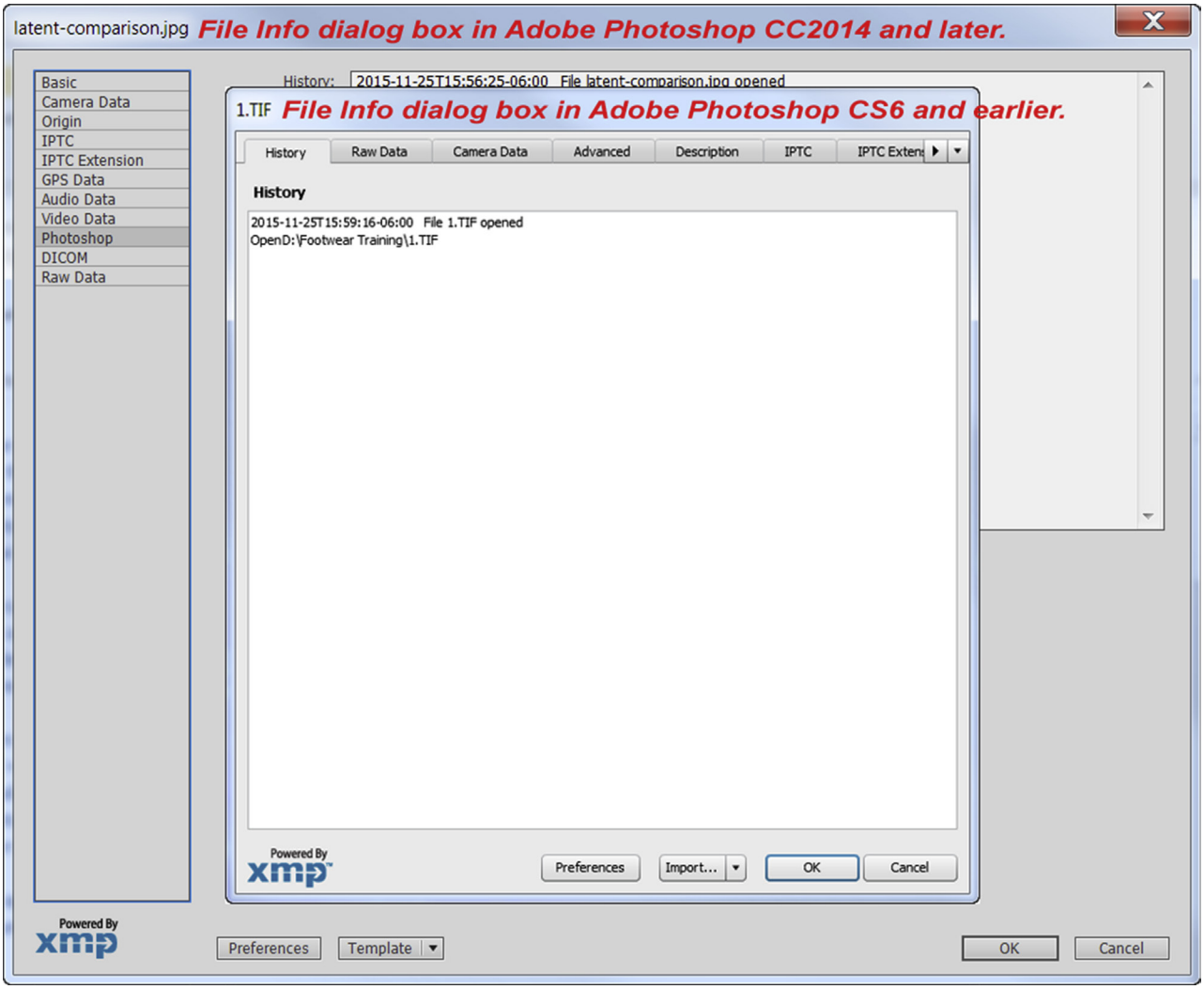


FIGURE 11.5
Once the History Log is enabled, the detailed settings and parameters can be viewed in the File Info dialog box.

5. Press and hold down the shift key, then click and release the left mouse button to highlight the entire history.
6. Copy the highlighted selection by pressing Ctrl + C.
7. Open a text-editing application, such as MS Word, Notepad, and WordPad, and create a new blank document. In the new blank document paste (Ctrl + V) the history copied in step 6.
   Following this procedure, the history is now in an editable document. Do *not* save the editable document file. Either print a hard copy of the document and then make copies of the printed file as necessary if additional copies are needed; OR use a PDF document creator application, such as Adobe Acrobat, to create a PDF file that contains the history file.
8. To ensure that the PDF file cannot be edited, change the Adobe PDF Security field to "Reconfirm Security for each job" and then click on the Edit button adjacent to the security option on the right side of the dialog box as shown in Fig. 11.6.
9. In the Adobe PDF Security dialog box shown in Fig. 11.6, enable (check mark in the box) the option for "Restrict editing and printing of the document. A password will be required in order to change these permission settings."
10. When the restrict editing and printing permissions are enabled, type a password in the Change Permissions Password field.
    Caution: Be very careful while typing the password as this dialog box does not require confirmation of the password to ensure that it has been entered properly!

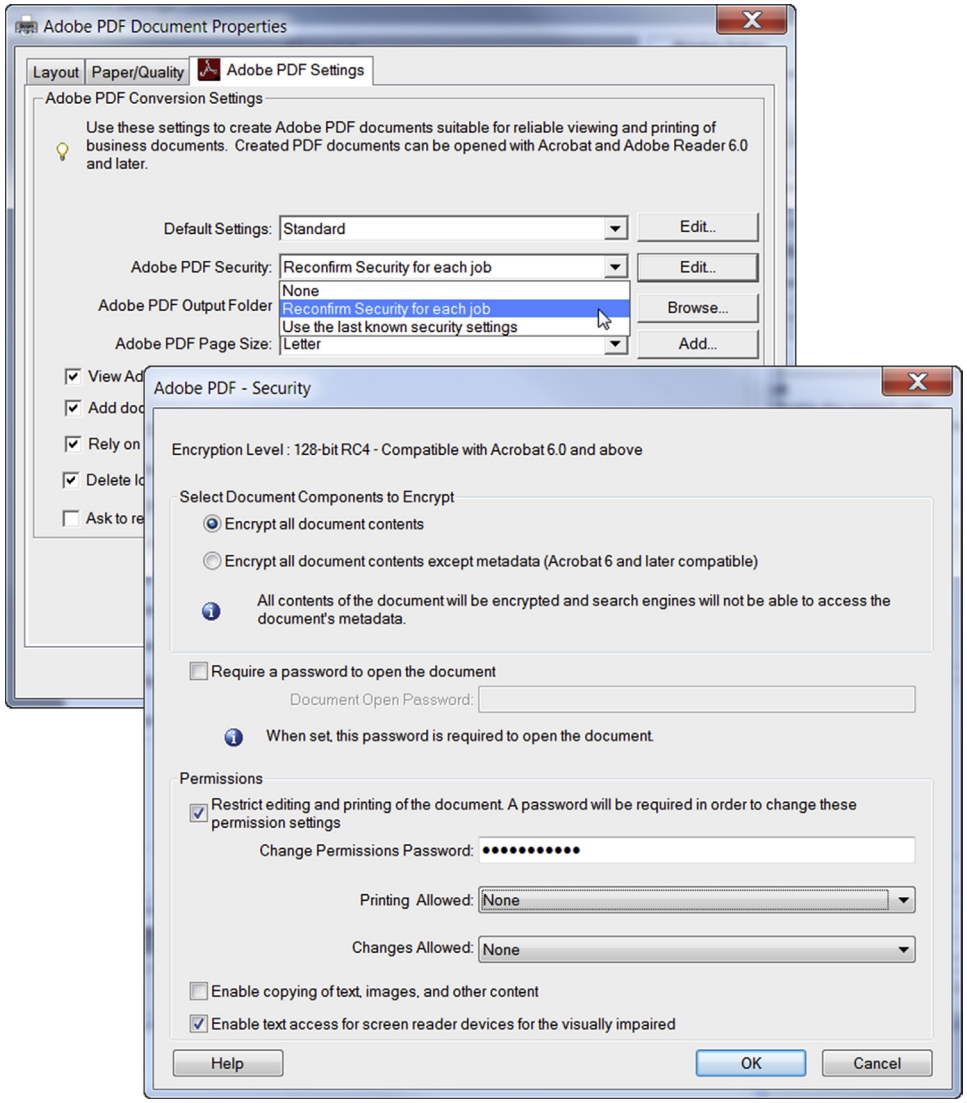


FIGURE 11.6
Some applications that create PDF documents, such as Adobe Acrobat, include the ability to define security settings to prevent editing or printing documents, thus ensuring that data can be locked down in a noneditable state.

11. Then click the OK button on the lower left corner of the open security dialog boxes, and then click the Print button or whatever button is appropriate depending upon what PDF software is being used.

I prefer not to provide a separate file, printed or electronic, as this becomes a "test" issue. (I will, however, give the DA's office or the State Attorney's office a copy of the history if requested with the understanding that it is not to be provided to any other attorney or other "expert.") The logic behind this process is that if the opposing expert is sufficiently qualified in Adobe Photoshop, then he/she should know how/where to find the history as well as how to read the history data in Photoshop. If the "expert" does not know how to find or read the history embedded in the image file, then how can the "expert" be "sufficiently qualified" to evaluate, discuss, and/or challenge the imaging process!

The History Log Versus History

Do not confuse the History Log with the History panel. The History Log and the History panel are used for completely different purposes. The History Log maintains a complete, detailed list of *all* processes performed on a digital image for *all* editing sessions, including the settings and parameters used for each process. The History window (opened from the Window menu option by clicking on the History option) displays only the names of the steps that have been used during the current image-processing session.

RULE OF THUMB 11.10

The History Log maintains a complete, detailed list of all processes performed on a digital image for all editing sessions, including the settings and parameters used for each process whereas the History window displays only the names of the steps that have been used during the current image-processing session.

Using the History window, you can step backward and undo a single step, or you can step backward and undo multiple steps at a time. The process of stepping backward is recorded as part of the History Log, but the steps no longer appear in the History after a different function is performed. (That is, the next step that you perform will then appear in the History window, and the previous steps will disappear; the new step together with the list of previous steps—as well as the number of steps backward—will be maintained in the History Log.)

One thing that is not recorded in the History Log but is recorded as part of the History is the list of steps performed using an Action (macro). Only the name of the Action is recorded in the History Log. Once an action is performed, the steps performed and shown on the History tab can be undone by stepping backwards one step at a time.

Actions created and used during image processing should be specified in the SOP. Alternatively, the steps can be printed and saved with the printed image in the case file.

To print the contents of an Action, highlight the name of the macro on the Actions palette; then press and hold the Ctrl and Alt keys and choose the Save Actions command. Photoshop will save the steps defined in the Action in a text file. You can use this file to review or print the contents of an Action.

Rotation, Resolution, and the Graphics Processor

> The phrase "to be, or not to be" comes from William Shakespeare's *Hamlet*, which was written around 1600. When considering whether or not to rotate an image, this soliloquy might be "To rotate, or not to rotate: that is the question: Whether 'tis nobler to suffer the consequences of Interpolation and aliasing by algorithmic processing, or just deal with a plethora of pixel problems ..."

While it is true that rotating an image may not adversely affect an examiner's or analyst's ability to affect their comparisons and should be permissible, this process does have a cause and effect on pixel values, which can have a significant effect on how the image is processed, such as whether or not background noise can be removed successfully, how color channels are used, so on and so forth.

When an image is rotated at any angle *other* than 90 degree, two issues arise:

1. The **Aspect Ratio** (the spatial relationship of the neighboring pixels to which each pixel is compared) of the object changes.
2. Pixel color values are interpolated, which means that color values that did not exist in the original image are created when the image is rotated, and the artifacts are extended across multiple pixels as shown in Fig. 11.7.

The good news is that the higher the image resolution, the less this impact is "visible" when rotating an image. Moreover, digital images should not be rotated more than ±45 degrees, and should never be rotated until after all digital image processing has been completed. If a rotation of greater than 45 degrees is required, use a negative rotation to rotate the image to a horizontal position and then rotate the image using a 90 degree rotation. For example, instead of rotating an image 75 degrees, rotate the image −15 degrees, and then rotate the image +90 degrees to minimize the rotation artifacts.

Rotation of a digital image should be postponed until after all digital image processing has been completed with the image. It is also recommended that the processed image be saved prior to rotating the image so that in the event additional image processing is required to adjust tonal range, etc., additional processing can be performed using the original pixel values and not the artifact values resulting from the rotation process. For example, to remove a color background from an image that has been rotated, additional derivative color values would have to be considered. Or, if a pattern removal filter was required to remove background noise in an image of a latent

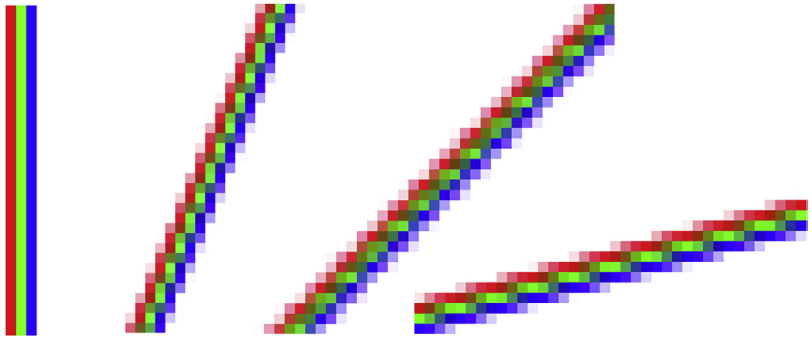


FIGURE 11.7
From left to right: The vertical Red (R), Green (G) and Blue (B) lines are each one pixel wide, for a row of three pixel values. When the lines are rotated at 22.5 degrees, the row of three pixels increase to alternating rows of four and five pixels; when rotated at 45 degrees, the row of three pixels increase to alternating rows of six and seven pixels; when rotated at 75 degrees, the row of three pixels expand to alternating rows of 15 and 16 pixels.

print, the pixel values for the noise and the ridge detail would become commingled when the image is rotated, thus making it significantly more challenging to remove the pattern as well as have a detrimental impact on the analysis of both level 2 and level 3 ridge detail.

RULE OF THUMB 11.11

If it is necessary to rotate the image after all image processing has been completed successfully, use the Ruler Tool to create an axis through the image and then click on the Straighten layer button on the tool bar. Adobe Photoshop will automatically rotate image using the least destructive method of rotation (ie, less than 45 degrees). Then it may only be necessary to rotate the image 90 degrees clockwise or counterclockwise, which does not create artifacts, to complete the rotation process.

For best practices, Adobe Photoshop's "Rotate View Tool" should be used during digital image processing as this tool changes only the appearance of the image on the screen without changing the underlying pixel values and without creating aliasing artifacts. This tool cannot be used unless the "Use Graphics Processor" feature is enabled in Preferences > Performance as shown in Fig. 11.8.

To use this tool, select the Rotate View Tool from the tool bar. Move the cursor on top of the image and click and hold the left mouse button; a compass will appear on top of the image. Hold the left mouse button down and move the cursor in a circular motion to rotate the image as desired, then release the left mouse button. The image can be restored to its original orientation by pressing the Escape (Esc) key.

Use the Rotate View Tool while processing the image, at least during the process of analyzing and suppressing background noise (color), converting the image to grayscale and while adjusting the tonal range and contrast of the image.

Adjustments, if any, made while the Rotate View Tool is active will be performed on the nonrotated pixel values, which means that the artifacts that must be considered after an image has been rotated are not a concern during the imaging process.

Note: In addition to enabling the Rotate View Tool, the Use Graphics Processor function also affects how images are resampled when they are displayed on the screen. As shown in Fig. 11.9, the lines on the top and right side of the image are visible when the function is enabled, but are not visible when the function is disabled. To more accurately view the actual pixel data in an image file when the image is zoomed out (resampled), the Use Graphics Processor function must be enabled in Adobe Photoshop Preferences.

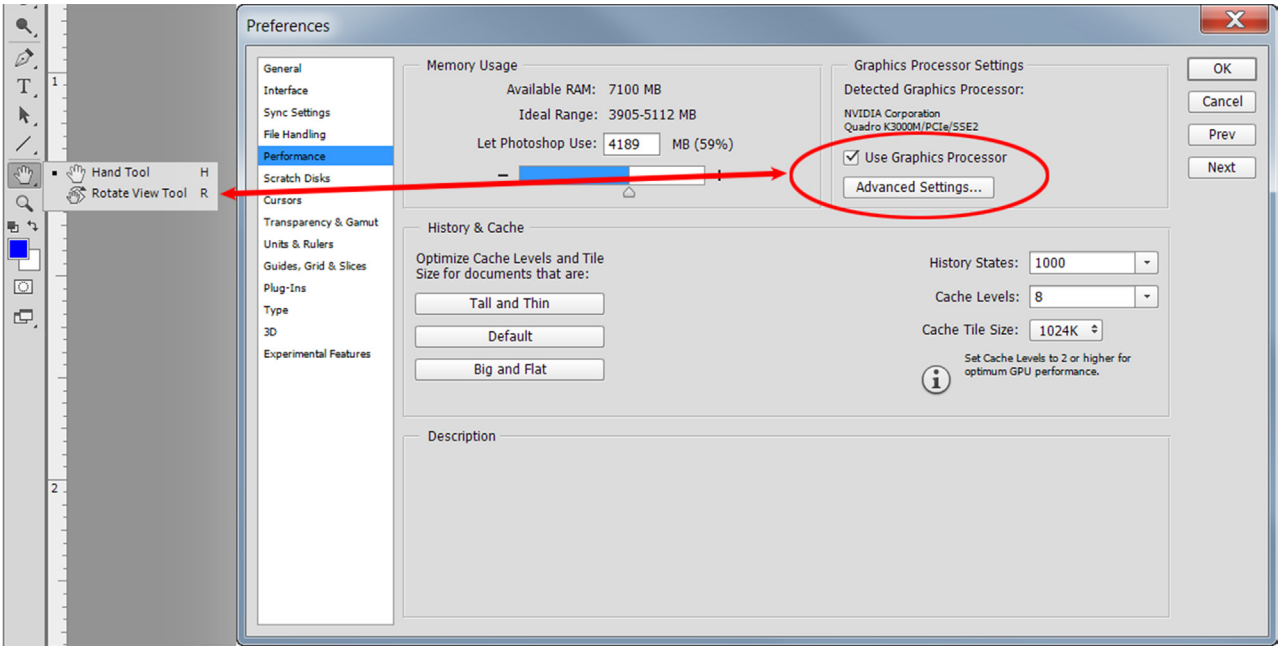


FIGURE 11.8
To enable the Rotate View Tool, the "Use Graphics Processor" feature must be enabled in the Performance settings for Preferences.

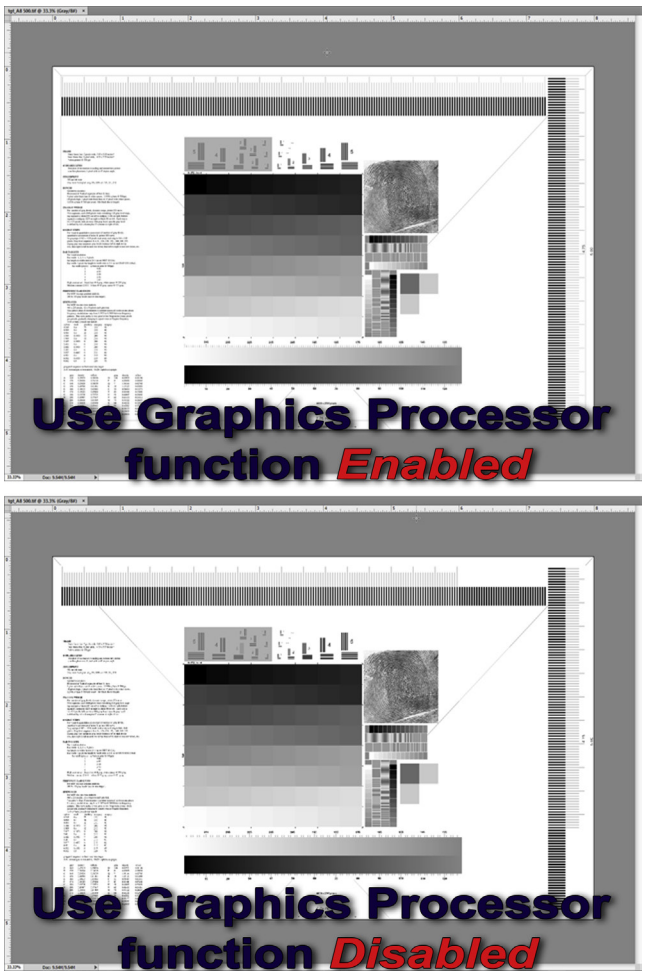


FIGURE 11.9
Other features, such as resampling options, are affected depending upon whether the "Use Graphics Processor" feature is enabled or disabled in the Performance settings for Preferences.

Resolution and Resampling

As stated in chapter "Digital Imaging Technologies," there are a number of monitor resolution settings. These settings are frequently controlled by the video card or by the monitor itself. As a result, images frequently must be resampled before the full image can be displayed on the monitor. The good news is that when an image is zoomed in or zoomed out for purposes of display, the actual content (pixel values) in the image is not changed.

There are, however, times when the actual resolution of the image must be changed so that the image will always produce a specific size/occupy a specific area. For example, if a specific system, such as an AFIS terminal requires an image to be 1000 PPI, and the image must always be 1.25″ by 1.25″, then all files received by the workstation must be exactly 1250 pixel by 1250 pixel, where the first 1000 pixel by 1000 pixel would occupy an area that is $1''^2$. The 0.25″ would require 250 pixel (1000 PPI divided by 4). If the requirement was 500 PPI, then all files received by the workstation must be exactly 625 pixel by 625 pixel, where 500 pixel by 500 pixel would occupy an area that is $1''^2$. If an image that measures 1250 pixel by 1250 pixel were shared with a system that requires 500 PPI, the image would occupy an area that is $2.5''^2$.

When calibrated, most images captured digitally using a 16 MP digital SLR camera have a calibrated resolution that is between about 1900 and 2900 PPI, depending upon the size of the area captured with that specific camera. Most AFIS providers now support a resolution of 1000 PPI for latent prints, which would mean that most, if not all, prints would have to be resampled and cropped to fit the specified resolution/size.

Even images scanned on a flatbed scanner must be resampled because there are no scanners available today that have a native resolution of 1000 PPI, unless the scanner has been "customized" for a particular imaging solution, such as for image acquisition on an AFIS workstation.

For optimum image quality and even resampling, the optical (hardware) resolution should be divided by 2, and each additional step to reduce the resolution (because of file size) should also be divided by 2. For example, the Epson Perfection V850 has physical (hardware) resolution of 4800 PPI. Scanning a 3-inch by 5-inch lift card using the scanner's full optical (hardware) resolution, the file size would be 988.8 MB, which would be an unmanageable file size. Therefore, to reduce the file size for a more manageable file size, divide 4800 by 2, or 2400 PPI, which would produce a file that is 247.2 MB, which is still an unrealistic file size for most law enforcement environments. To divide the resolution by 2 again would yield a resolution of 1200 PPI, for a file size of 61.8 MB, which is a more manageable and realistic file size.

The reason for dividing by two instead of any other number is because of a resampling issue. When resampling, it is important to have an even resampling or a ratio of 2 to 1. For example, in resampling an image containing 1000 pixel using a divisor of 2, the 2:1 resampling ratio would be 2:1 or 50%. Using a divisor of 3, would yield a 3:1 ratio or 33.3333333333333%. Since pixels are a singular entity, there is no way to equally handle a 0.3333333333333 pixel.

The bottom line is that using a divisor of 2 works in every case. There are exceptions where it is possible that using a divisor of 2 or a divisor of 3 would result in an even value at some point, but that would be rare. Again using a resolution of 1200 PPI and a divisor of 2 would yield, 600, 300, and 150; using a divisor of 3 would yield 400, 133.3333333333333, and so on, even as 400 PPI is a ratio of 3:1.

In Fig. 11.10, all of the line pairs are visible when the image is viewed at 100%. At 66%, the #1 line pairs are displayed as two or three lines. At 50%, the #1 line pairs and white spaces are averaged together where it shows an area that is consistently shaped with the line pairs, and the #2 line pairs are still visible as are the #3 line pairs. At 33%, the only line pairs that are visible are the #3 line pairs, and at 25% even the #3 line pairs are resampled down to only three visible lines.

The bottom line is that the lower the resultant PPI, the loss of detail becomes more visible; hence using a divisor or multiplier of 2 whenever possible to maintain the highest possible resolution (50% or 2:1 ratio).

A Brief History of Scanners and Resolution

Even though scanners create three separate values for each diode on the imaging sensor—red, green and blue—and those values are used to create a single pixel value, the measurement used to specify image quality for flatbed scanners is referred to as dots per inch (dpi) even though they do not use a cluster of dots to represent a single pixel value. This misnomer dates back to the 1950s when the first photocopy machines were being developed. (Xerographic office photocopying was introduced by Xerox in 1959.) As the technology became more popular, different techniques were used to make the "copies" of the original document. One of these techniques involved the use of toner, in which toner was deposited onto spots (aka "dots") that were negatively charged. The quality of the output was measured on the

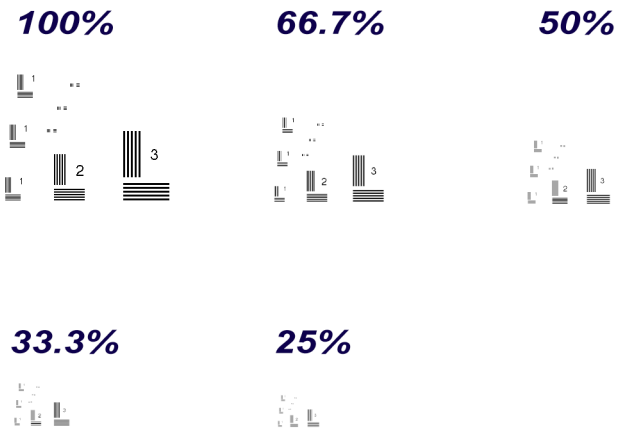


FIGURE 11.10
The 1:1 (100%) resampling shows a series of line pairs, where the line pairs marked 1 are 1 pixel wide, separated by a white space that is 1 pixel wide; the line pairs marked 2 are 2 pixel wide separated by a white space that is 2 pixel wide; and the line pairs marked 3 are 3 pixel wide separated by a white space that is 3 pixel wide.

number of dots that could be placed on the imaging drum. Then the toner was transferred to a piece of paper and melted onto the paper by heat and pressure rollers. Even though the technologies for scanners and printers have been relegated to separate boxes (ie, flatbed scanners and printers), the "quality indicator" for printers and scanners today still remains dpi, although scanners now create high-resolution images based upon picture element (pixel) value. The Epson Perfection V800 and V850 have a separate scan head for transparencies that has 6400 photo receptors for a 1-inch (6400 PPI) area, which is far greater resolution than any printer available today.

Resolution Resampling: "Upsampling" and "Downsampling"

Now that we have had a history lesson in dots and pixels, let us get back to the issue of resampling. To change the number of pixels contained in a digital image file, the pixel values must be resampled. There are two types of resampling: "upsampling" and "downsampling." An example of downsampling is decrease in the number of pixels in an image, such as when a picture is reduced in size to produce a thumbnail; conversely, an example of upsampling is when there is an increase in the number of pixels, such as when a picture is increased in size so a small image can be printed as a large picture.

RULE OF THUMB 11.12

There are two types of resampling: "upsampling" and "downsampling." Downsampling decreases the number of pixels in an image, whereas upsampling increases the number of pixels.

Stated another way, downsampling means discarding actual pixel values and using a single substitute value to represent multiple pixel values. Upsampling means additional pixel values are created using the original pixel values. (Some refer to downsampling as "desecration," and upsampling as "counterfeiting." While I believe these terms are a bit harsh, I have seen images that were desecrated because of the level of downsampling, so maybe the term is not so harsh after all!)

Adobe Photoshop provides a number of different resampling methods, including:

- Automatic is a method of resampling where Photoshop chooses the method of resampling based on the contents (pixel values) of an image and whether pixel values are being added to or being removed from the image.
- Preserve Details is a resampling method, like Bicubic Smoother, that is intended for enlarging images. However, with this method, a Noise reduction slider is used for reducing the noise as additional (new) pixels are added to the image.
- Bicubic Smoother is a resampling method primarily intended for enlarging images where the added pixel values are based on surrounding pixels to produce pixel values with smoother tonal gradients for the added pixels.
- Bicubic Sharper is a resampling method primarily intended for reducing the number of pixels where the remaining pixel values are based on the original surrounding pixel values and then sharpened to maintain contrast.
- Bicubic resampling is a more precise method of adding or removing pixel values based on surrounding pixel values to produce smoother tonal gradations without edges than Nearest Neighbor or Bilinear.

- Nearest Neighbor resampling is based on pixel values where non-antialiased hard edges are preserved.
- Bilinear resampling adds or removes pixel values based on averaging the pixel values of surrounding pixels producing medium quality results.

One method is not always the best solution for all types of images.

To provide an idea of what resample does to an image, Figs. 11.11A–C illustrate the artifacts of changing the actual number of pixels in an image file using different resampling options.

It should be noted that images often do not have to be downsampled to view a full image on a monitor depending, of course, on the resolution of the monitor and the number of pixels contained within the actual image file. Almost all images must be downsampled for printing, in which case actual pixel values are discarded and the remaining pixel values go through a process called dithering where the pixel values are converted to a cluster of dots (creating an approximate color value of the pixels being printed from a mixture of the color values and dot sizes available in the printer). Further, since the monitor can display a significantly higher number of pixels than a printer can print, more and more forensic examiners are relying on high-resolution monitors for their analysis and comparison. In addition, they can zoom in and zoom out to take advance of every single pixel value contained within an image since the image detail is not physically lost as it is in the case with printing. On-screen analysis and comparison can provide a significantly higher level of accuracy, especially when looking for level 3 fingerprint detail such as the size and shape of pores, size and shape of ridge edges, incipient ridges, and so forth. Speaking from personal experience, during image analysis and comparison, bigger is better!

RULE OF THUMB 11.13

Almost all images must be downsampled for printing, in which case actual pixel values are discarded and the remaining pixel values go through a process called dithering where the pixel values are converted to a cluster of dots (creating an approximate color value of the pixels being printed from a mixture of the color values and dot sizes available in the printer).

IMAGE-PROCESSING TECHNIQUES AND PROCEDURES

As stated earlier, there are some basic guidelines for image processing, although there are no specific requirements or mandates that describe how each tool or function should be used. The primary reason is that it is impossible to define every possible image scenario as well as every possible combination of tools that could be used for each scenario. The following sections do, however, try to provide a foundation that can be expanded upon by using these techniques on a wider range of digital imaging situations.

In what follows, tools and processing techniques are offered *only* as a recommendation on how these tools may be used. The application of these tools is consistent whether processing impression evidence, an **Alteration** on a questioned document, the results of serial number restoration on a firearm, for processing trace evidence for comparison, and so forth. There are always exceptions to every rule, but hopefully these guidelines will lead down a path of success processing a wide range of digital images from an even wider range of disciplines.

As discussed earlier in this chapter, there are a number of tools, techniques, and processes that can be used throughout the process. Plus, Adobe Photoshop typically provides one or more tools and techniques that generate a similar result, and there are typically two or more options for performing a single task, such as menu options, short cut keys, as well as keyboard short cuts. For example, there are several techniques for zooming in and out on an image: (1) use the zoom tool to zoom in or out, (2) use Ctrl plus the + (plus) key to zoom in and the Ctrl plus the – (minus) key, or (3) press and hold the Alt key while scrolling forwards with the wheel on the mouse to zoom in or scrolling backwards to zoom out.

The enhancement process should be defined to allow only commonly accepted image-processing techniques that improve the visualization (quality) of the image without adding or removing features (content) that were not present when the digital image was captured. Generally speaking, this means that only those processes that model darkroom techniques should be used. Techniques that are used to alter the content should not be permitted. Proper training in the use and implementation of image-processing techniques is also crucial, and not only in terms of knowing what to do and how to do it, but also in terms of explaining what enhancement techniques were used as well as why they were used (ie, how did the tools and image-processing techniques improve the quality of the image and what impact did that improvement mean in terms of visualizing the image more clearly for a more accurate and reliable analysis and conclusion).

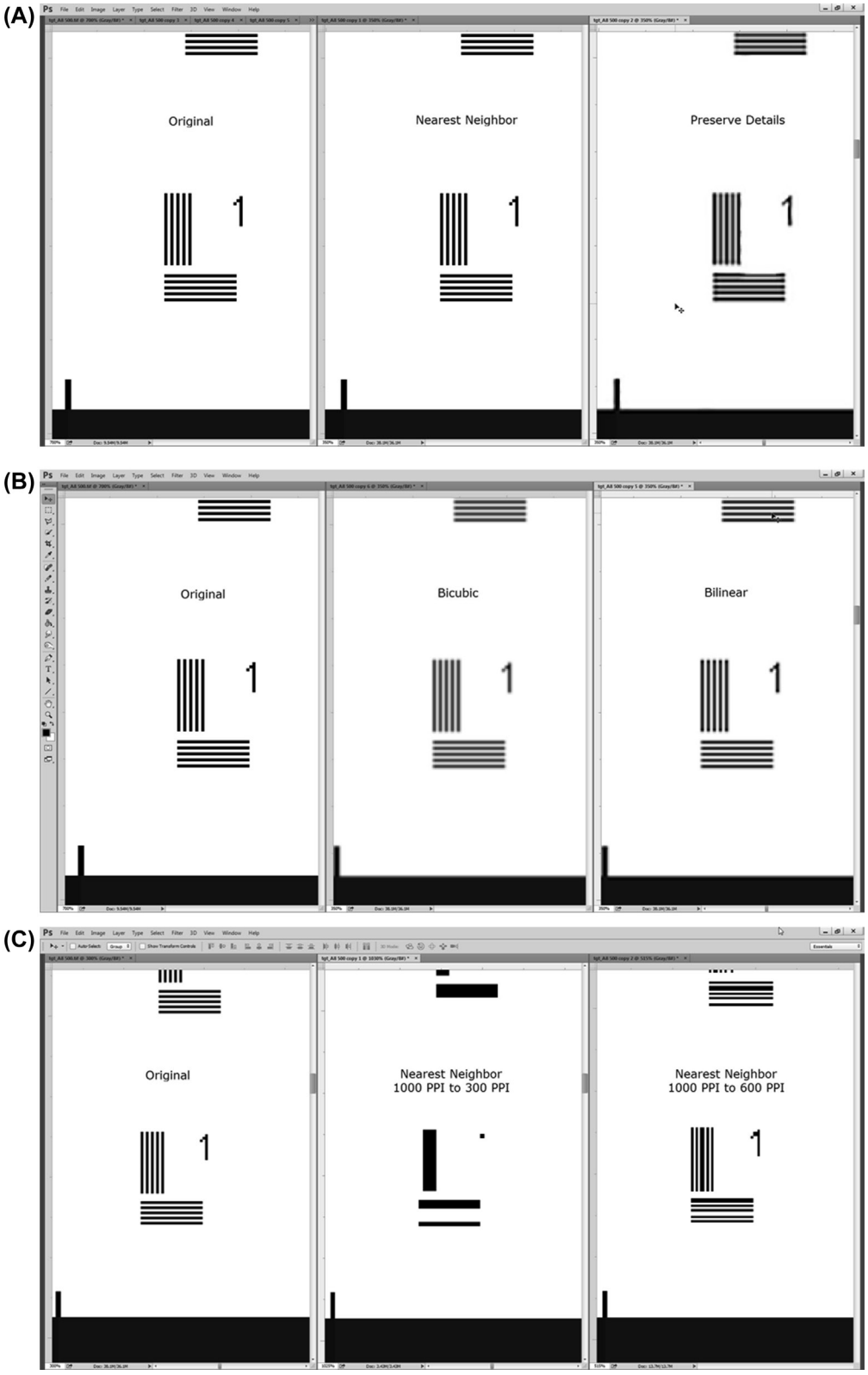


FIGURE 11.11
(A) Artifacts are created when the original image resolution is upsampled from 500 to 1000 PPI using Preserve Details resampling while no artifacts are created using Nearest Neighbor. (B) Artifacts are always created when the original image resolution is upsampled from 500 to 1000 PPI using Bicubic and Bilinear resampling. (C) Downsampling creates artifacts when the original image resolution is changed from 1000 to 300 PPI using Nearest Neighbor and from 1000 to 600 PPI using Nearest Neighbor.

RULE OF THUMB 11.14

The enhancement process should be defined to allow only commonly accepted image-processing techniques that improve the visualization (quality) of the image without adding or removing features (content) that were not present when the digital image was captured.

While an entire book could be written on the digital processing of evidentiary photography alone, the objective of this chapter is to help foster a better understanding of the imaging process as well as provide a better understanding of the most commonly used techniques in Adobe Photoshop for the digital processing of evidentiary photography.

In addition, many of the instructions provided in this section are based upon the use of the tools for the digital processing of latent prints because the latent print community probably by far does more digital image processing than any other forensic discipline. But while the discipline may be different, the use and application of the tools and processes described in this chapter is the same.

The following list of shortcut and Photoshop tips are provided to help you successfully perform the processes and tasks described in this chapter.

Basic Shortcuts

Ctrl + K	Displays the General preferences dialog box
Ctrl + S	Saves the file to disk; in the case of a camera RAW image, displays the Save As dialog box
Alt + Ctrl + S	Displays the file Save As dialog box
Ctrl + P	Displays the Print dialog box
Alt + Ctrl + I	Displays the Image Size dialog box
Ctrl + I	Inverts the image from Black and White to White and Black
Ctrl + L	Displays the Levels Dialog box
Ctrl + M	Displays the Curves Dialog box
Ctrl + R	Toggles Ruler on/off
Ctrl + H	Toggles Guides, Grids and Slices (aka Extras) on/off
Ctrl + A	Select All
Ctrl + C	Copy
Ctrl + D	Deselects a selected area (aka “kills the marching ants”)
Ctrl + V	Paste
Shift + Ctrl + N	Creates a new blank layer on the current image
Shift + F6	Displays the **Feather** Selection dialog box
Right mouse click on Ruler bar on the left or top of the image window	Allows you to change units of measure (ie, change ruler and image size settings from Inches to Centimeters, etc.)
D	Hitting the D key resets the color pallets to default values (ie, Black foreground and White background)

Display and Navigation tools

Tab	Hides/Redisplays (toggles) the Photoshop Toolbar (and Tool Options Bar beneath the menu bar) and the Palettes
Shift + Tab	Hides/Redisplays (toggles) just the Palettes and leaves the Toolbar and Tool Options Bar on the screen
Caps Lock	Toggles between precise mode (cross hair cursor) to cursor mode (function icon, ie, toggles between cross hair and circle when using a brush tool)
Spacebar	Move image in display window
Shift + Spacebar	Move two or images simultaneously when images are displayed side by side
Ctrl + Left mouse click	Quick select of layer when using the Move (V) tool
Alt + Left mouse click	Quick duplicate of currently selected layer when using the Move (V) tool
Ctrl + +	Zoom In
Ctrl + –	Zoom Out

History

Alt + Shift + Ctrl + I	Displays the File Info dialog box
Ctrl + Alt + Z	Step backward (used to step back multiple steps—not to be confused with Ctrl + Z, which is just a toggle switch to toggle back and forth between the last step and undo or redo the last step)
Ctrl + shift + Z	Step forward (used to step forward multiple steps—not to be confused with Ctrl + Z, which is just a toggle switch to toggle back and forth between the last step and undo or redo the last step)

SELECTING TOOLS FROM THE TOOLBAR

Most of the tools on the Toolbar in Adobe Photoshop have multiple options (ie, tools that can perform similar tasks). There are three different ways that a tool can be selected. *Note*: Once a tool is selected in Adobe Photoshop, that tool will remain active until another tool is selected. Some tools can inadvertently be troublesome, so when using the crop tool, a brush (pencil) tool, type tool, and so on, it is strongly recommended and encouraged to select a nondestructive tool, such as the Move tool, which can be selected easily by typing the letter v.

Place the cursor over the desired toolbar function, press and release the right mouse button to display all of the tools available for that function. Move the cursor over the appropriate tool and click the left mouse button to make it the active tool.

Place the cursor over the desired toolbar function, press and hold the left mouse button until the list of options available for that function is displayed. Then move the cursor over the appropriate tool and click the left mouse button to make it the active tool.

Type the letter for the desired toolbar function. When multiple tools are located in the same position such as the Eyedropper Tool as shown in Fig. 11.12, which is selected by typing the letter i, the additional tools can be selected by pressing and holding the Shift key while typing the letter i. Continue holding the shift key and type the letter I again to scroll to the next tool that is available as part of the Eyedropper Tool functions, and the corresponding cursor for that function will be displayed on the screen. For example, to enable the Ruler Tool, type the letter i to choose the Eyedropper Tool, then press and hold the shift key and type the letter i to scroll to the 3D Material Eyedropper Tool, type the letter i again to scroll to the Color Sampler Tool, and type the letter i one more time to scroll to the Ruler Tool. The ruler tool will remain active until another tool is selected. Until that time, typing just the letter i will select the Ruler tool without having to scroll through the other options.

Fig. 11.13 is an overview of the tools provided on the toolbar in Adobe Photoshop CS4 and later, including CC.

Calibrating Digital Images

Images captured using digital cameras must be calibrated (scaled) for 1:1 life-size output because there is always a variable distance between the lens and the object. In other words, the same digital camera may be used to capture a small area or a large area, such as a single latent print, a palm print, a footwear impression, or a bloodstain by moving the camera closer to or further away from the object and by changing the lens.

RULE OF THUMB 11.15

Images captured using digital cameras must be calibrated (scaled) for 1:1 life-size output because there is always a variable distance between the lens and the object.

In contrast, there is no variable distance (depth of field) when scanning images on a flatbed scanner. The object is placed directly onto the face of the scanner, so the scanner knows both the physical size of the scanned area and the resolution. As a result, images acquired using flatbed scanners are captured as true, life-size images. (That is, of course, unless you are scanning an image that was enlarged previously and you want to scan the image so you can restore the image back to life-size scale.)

For example, using a 6-megapixel digital camera to capture an image, where the imaging sensor in the digital camera has a resolution of 3008 pixel by 2000 pixel: a 2-inch by 3-inch area could be photographed, or a 4-inch by 6-inch area could be photographed; it makes absolutely no difference to the camera because the camera has no idea of the size of the captured area; the camera knows only that the image contains 3008 pixel by 2000 pixel.

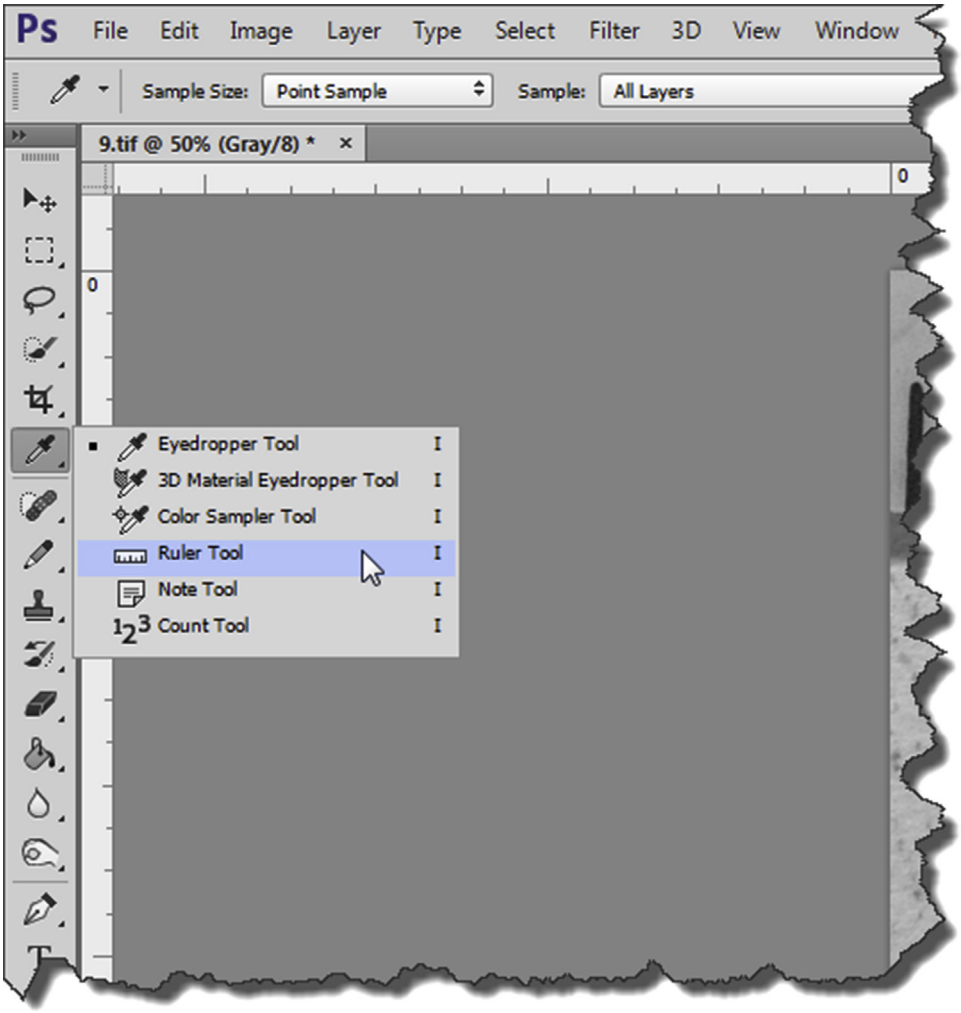


FIGURE 11.12
Adobe Photoshop frequently groups multiple tool options on the tool bar for easy identification and quick selection.

Using Adobe Photoshop, any image can be calibrated as long as the image has a scale in it. (Alternatively, there are commercially available plug-ins for Photoshop that automate the image calibration process as well.) *All* image calibration techniques—whether manual or automated—are based on the Pythagorean theorem where the number of pixels equals the length of segment from Point 1 to Point 2.

While digital images are two dimensional, there are three attributes that make up size of any digital image: width, height, and resolution. The first two are "measurable" physical attributes. The third is a more obscure or technical attribute (PPI) used primarily to scale the image properly for display on a computer screen or for output using a printer. By knowing any one of the three attributes, the computer can calculate the other two components of image size.

There are two primary techniques commonly used in Adobe Photoshop to calibrate a digital image. One technique is often deemed to be easier, but that technique has limitations when calibrating large objects, such as footwear, tire tread, and blood spatter. The second technique is a bit more intensive, but can provide a higher degree of accuracy because distortion is more readily identified. Both techniques are described in this section, so you can choose the option that works the best for you.

Calibrating Digital Images: Option 1

Option 1 is frequently used to calibrate small digital image, such as latent prints or marks. In this case, the size of the entire captured area is usually less than 3″ × 5″, or perhaps larger if a latent palm print was captured. Option 2 provides the ability to identify distortion (such as lens or barrel distortion) and issues (such as the imaging sensor in the digital camera not being parallel with the object being photographed).

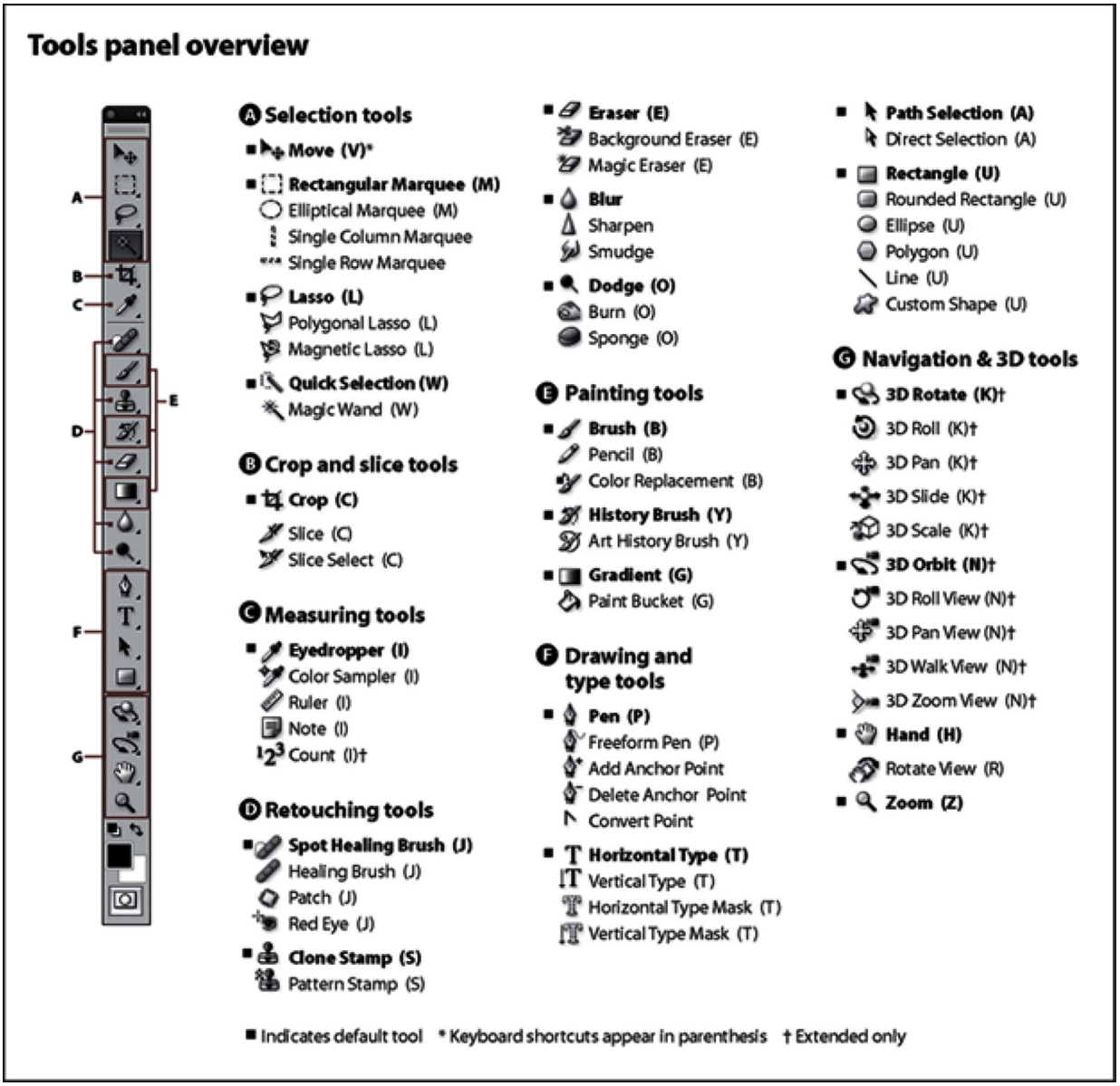


FIGURE 11.13
This table displays the tool options and tool groups for the Tool Bar in Adobe Photoshop CS4 through CC.

1. Open the image to be processed.
2. Turn on the Rulers view by pressing and holding the Ctrl key while typing the letter R, *or* from the View menu select Rulers. Rulers will appear at the top and left edges of the window that contains the image.
3. Move your cursor and position it so that the cursor is sitting on top of the Ruler bar at the top of the image window and click the right mouse button to display the Ruler options:
   a. Pixels
   b. Inches
   c. Centimeters
   d. Millimeters
   e. Points
   f. Pics
   g. Percent
4. Choose Inches if the scale in the image is an inch scale or choose Centimeters if the scale in the image is metric. (Photoshop automatically converts the values shown in the Image Size dialog box, so do not make any changes to the scale settings in the Image Size dialog box.)

5. On the Photoshop Toolbar, select the Ruler Tool shown earlier in Fig. 11.14; the Ruler Tool options will also appear on the tool options bar located directly beneath the menu bar at the top of the window.
6. From the Image menu, choose Image Size (or display the Image Size dialog box by pressing and holding the Alt and Ctrl buttons simultaneously while typing the letter I).
7. Click in the checkbox next to Resample Image if a checkmark appears in box; if the checkbox does not have a checkmark in the box, do *not* click in the checkbox. *It is crucial that the resample image option is disabled* (no checkmark in the Resample Image box). The fields Width, Height, and Resolution will be linked as shown in Fig. 11.15.

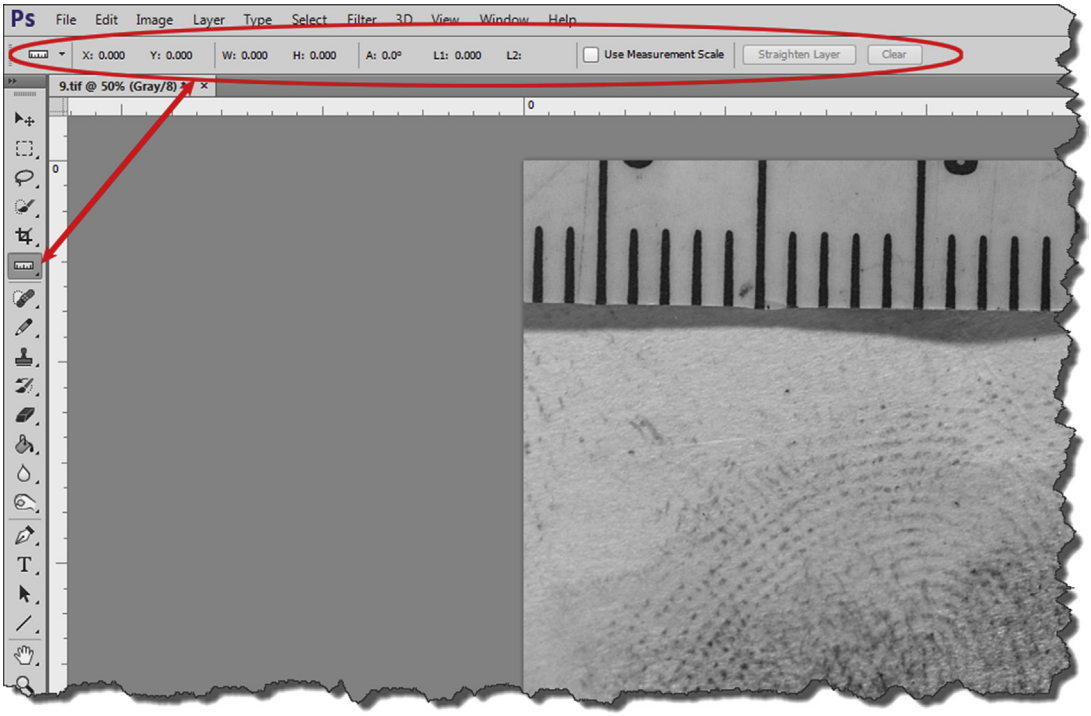


FIGURE 11.14
When choosing tools, such as the Ruler tool, the settings, parameters and other options for the specific tool are displayed on the Tool Option Bar, which is located directly beneath the menu bar at the top of the window.

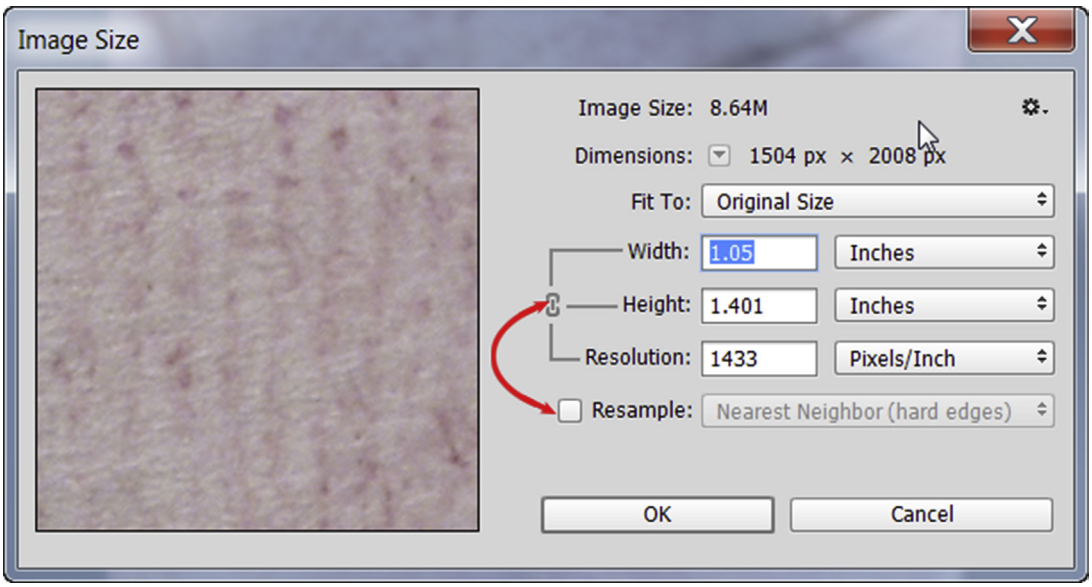


FIGURE 11.15
During image calibration, the Resample option must be disabled, which links the Width, Height, and Resolution values together so that the image can be sized properly without adding or removing pixel values contained in the original image.

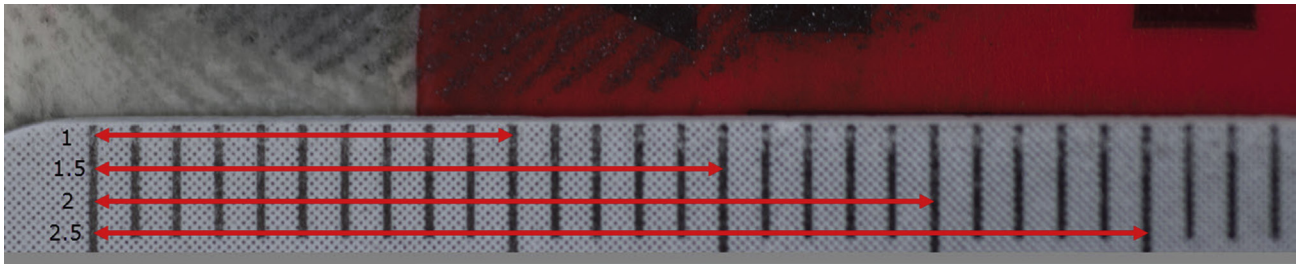


FIGURE 11.16
When calibrating images, segments can be defined as any length. However, the longer the segment used for calibrating the image, the more accurate the image size will be.

8. In the Resolution field, change the value appearing in this field to 1 or the desired segment length used for sampling; the longer the segment, the larger the sample and the more accurate the Image Resolution. For example, as shown in Fig. 11.16, the segment length options are: 1 (10 mm), 1.5, 2, or 2.5 cm. Type the desired segment length into the Resolution field in the Image Size dialog box.
   Note: Do not change the Resolution from Pixel to Inch. As stated above, Photoshop will automatically convert the metric sample to pixels per inch based when the Rulers are set to Centimeters as described in step 4 above.
9. Click the OK button to close the Image Size dialog box.
10. Position the Ruler Tool at a starting point on the scale in the image, then click and hold the left mouse button and drag the Ruler Tool cursor to the desired ending point (indicating the length of the sample as defined in step 8 above).
    Caution: For accurate image calibration, be sure to follow these three critical rules:
    a. Measure from the *center* of the starting scale bar to the *center* of the ending scale bar. Positioning the cursor at the left edge of the beginning scale bar and dragging to the right edge of the ending scale bar will cause image to be calibrated improperly and the scale will not align properly when a scale is placed next to the scale in the printed image. The scale in the printed image may align properly for a short distance, but further along the scale, the scale in the printed image will no longer line up properly. This is particularly true when calibrating a large object based on just a single centimeter or a single inch. For example, if you calibrate an image that is 6 cm wide and you are off by 9 pixel (3 pixel off center on the left scale bar and 6 pixel off center on the right scale bar) when you measure 1 cm, then that error rate is applied for the entire 6 cm for a total margin of error of 54 pixel. Again, on a small image, this may not be significant. But the larger the object, the more apparent this error becomes.

RULE OF THUMB 11.16
When calibrating a digital image, measure from the center of the starting scale bar to the center of the ending scale bar regardless of which option is used for calibration.

    b. When clicking and dragging the cursor to create the segment length line, the line *must be parallel to the edge of the scale* in the image.
    c. Use an area on the scale for the segment line that is not distorted. (For example, part of the scale appears in focus while the other part of the scale appears out of focus, the space between the bars appears smaller or larger in the scale, or the scale appears curved in the image.)
11. Locate and note the value shown for Line 1 (*L1*) on the Ruler ribbon, which is located directly beneath the menu bar as shown in Fig. 11.17.
    Note: Do *not* use the Width (*W*) or Height (*H*) values as these values do not account for scales that may appear at an angle. For example, when the scale appears at an angle greater than about 5 degree, the length of the segment could make a significant difference in image size.

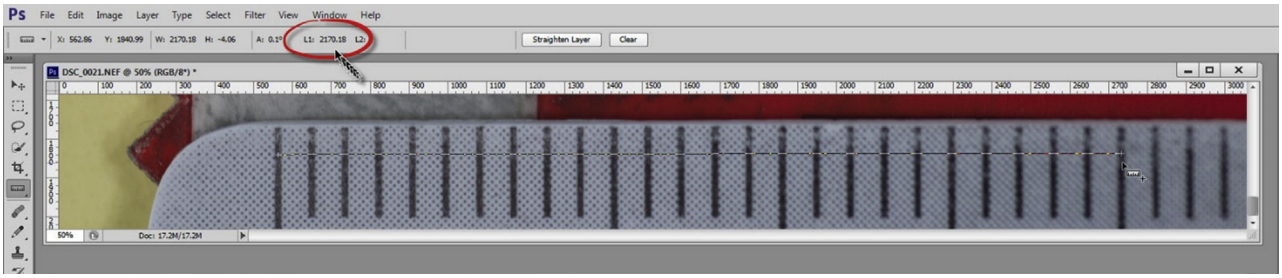


FIGURE 11.17
Enter the resolution value shown for L1 in the Image Size dialog box. If a decimal value is included as part of the L1 number, do not enter it when entering the resolution value.

In addition, there is a known bug (issue) that has existed in Adobe Photoshop since at least Adobe Photoshop CS4. The Extended editions of Adobe Photoshop CS versions as well as all versions of Adobe Photoshop CC have an option on the Ruler Tool options bar called "Use Measurement Scale." Frequently, the first time an image calibrated during a Photoshop session has a problem whereby the L1 value is not correct (does not update automatically based on the type of measurement selected on the Ruler). To resolve this error and ensure that the L1 number is correct, enable the Use Measurement Scale option by clicking in the checkbox to the left of this option (a checkmark appears in the checkbox). Then disable the Use Measurement Scale option by clicking in the checkbox to the left of this option (no checkmark appears in the checkbox). You can "guestimate" whether or not the image is calibrated properly by comparing the scale in the image with the Ruler at the top and left side of the image window.

12. Open the Image Size dialog box again by either choosing Image Size from the Image menu or by pressing and holding the Alt and Ctrl buttons simultaneously while typing the letter I.
13. Confirm once again that the Resample Image option is disabled (no checkmark in the Resample Image box as shown in Fig. 11.15).
14. In the Resolution text box, type the L1 value identified in step 11. (The Height and Width values will change automatically using the new Resolution value.)
15. Click the OK button to close the Image Size dialog box.
    The digital image is now calibrated and the image can be printed as a life-size (1:1) print. In addition, if the image contains a fingerprint impression that must be submitted to an AFIS system, the resolution can now be changed to correspond to the resolution required by the particular AFIS vendor. *However, the resolution must be changed with the Resample Image option in the Image Size dialog enabled (a checkmark must appear in the checkbox).*

Calibrating Digital Images: Option 2

Option 2 uses the Crop tool for selecting the segment length and is frequently used for calibrating larger objects, such as footwear impressions, tire tread, firearms, and blood spatter. In most of these instances, the area captured in the image is typically larger than 8″ by 10″. Option 2 also provides the ability to identify distortion, such as lens or barrel distortion and issues where the camera is not parallel with the object being photographed. Using the crop method also provides additional (more accurate) benefits:

- The image can be zoomed in (using either Ctrl + 1 or Ctrl + + to zoom in to 100%) to verify that the crop line is placed in the middle of the starting scale bar as well as to the middle of the ending scale bar, thus ensuring the highest degree of accuracy when selecting the segment length. When zoomed in on the image, use the red area box in the Navigator window, the zoom slider bars on the right, and bottom sides of the image window, or the Navigator Hand (press and hold the spacebar to display the Navigator Hand tool cursor) to move between the beginning point and the ending point of the cropped area.
- If the crop box does not appear in the middle of the bar on the scale, adjust the position (location) of the crop box line to ensure better accuracy.

1. Select the Crop tool from the Photoshop toolbar, as shown in Fig. 11.18.
2. Position the cursor at the starting point on the upper corner of the scale; click and hold the left mouse button and drag the cursor to the ending point on the lower right corner where "Marching Ants" are displayed for the crop area before releasing the left mouse button. A crop box will appear, as shown in Fig. 11.19.

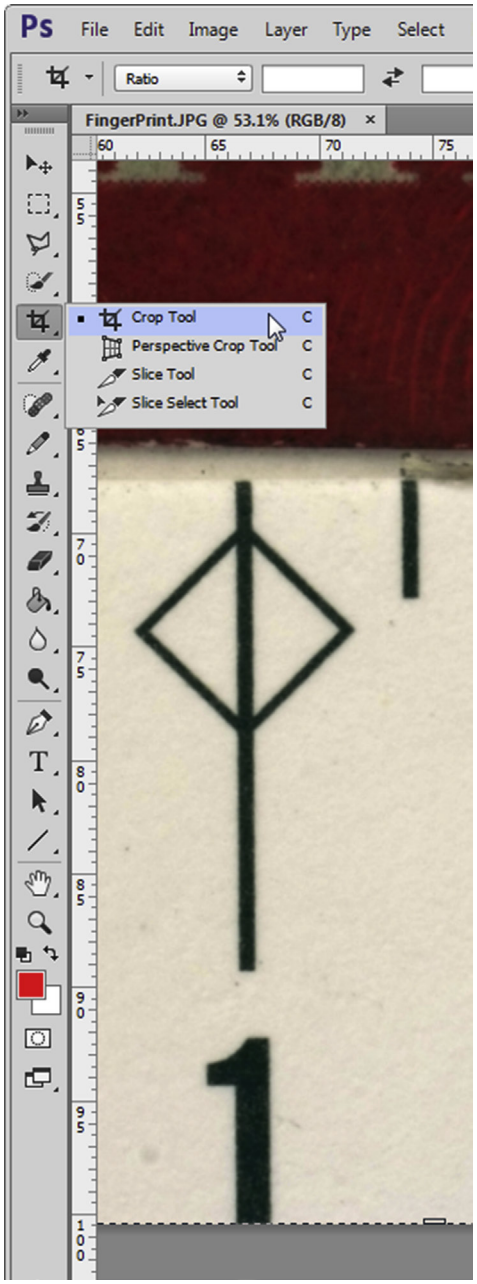


FIGURE 11.18
There are two commonly used methods for calibrating digital images. One method involves the use of the Ruler tool, and the second method uses the Crop tool. Regardless which technique is used, the Ruler tool and the Crop tool do the same thing: they define the length of the segment for calibrating the digital image.

Note: Ensure that the crop box lines appear in the middle of both the starting and ending scale bars. For maximum accuracy, the longer the segment, the more accurate the results. While zoomed in, look for distortion (such as the edge of the scale curves outside the crop box line; and the scale bars appearing in focus at one end of the scale but to not at the other end of the scale in the image; and so on).

If the item was photographed with the scale at an angle in the digital image, the image must be rotated to match the scale.

a. Once the crop tool is selected, a crop box appears around the outside edge of the image. Move the cursor outside the crop box, and the cursor will become a "two-headed" (curved) cursor. Click and hold the left mouse button, and drag the cursor to rotate the image as shown in Fig. 11.20.
b. Using the grid inside the crop box as shown in Fig. 11.20, align the edge of the scale with the grid lines.

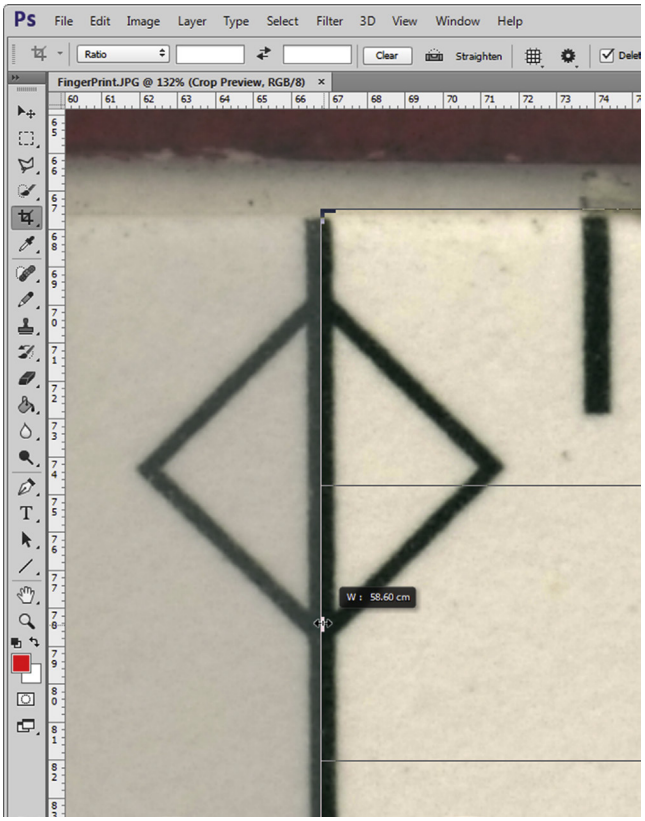


FIGURE 11.19
Regardless of which calibration method is used, the starting point of the Ruler tool or the Crop box must begin in the middle of the starting scale bar in the image and must end in the middle of the ending scale bar for maximum accuracy.

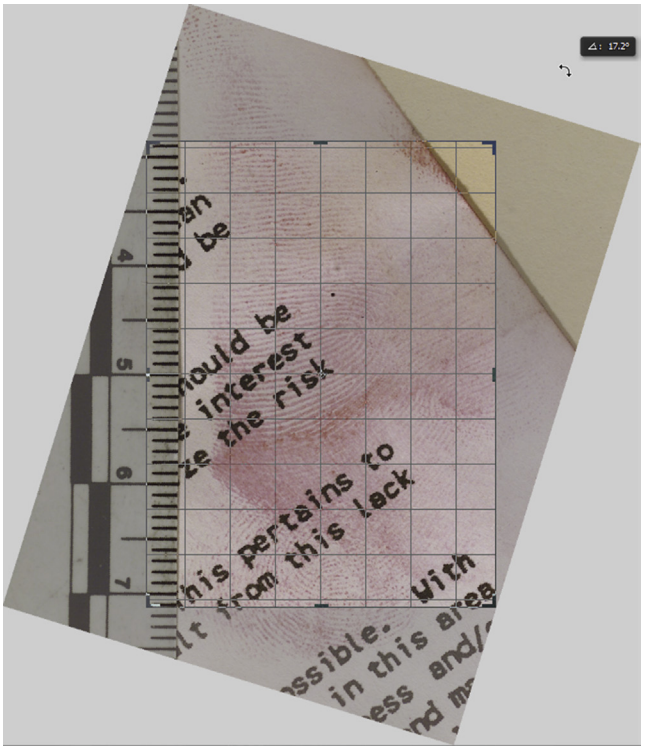


FIGURE 11.20
If the scale was placed at an angle when the image was photographed, the image must be rotated so that the scale is parallel to the guidelines when using the Crop method for calibrating digital images.

   c. When the image is rotated properly, position the cursor on top crop box handle (the crop box handles are the thick, black boxes in the four corners of the crop box and in the middle of the crop lines on the four sides of the box), then click and drag the crop line so that it is positioned in the middle of scale bar at the top (or click on the left crop box handle and drag the crop line so that it is positioned in the middle of the scale bar on the left side of the image if the angle of the scale in the image caused the image to rotate so that the scale was on the bottom of the image instead of the right side of the image).
   d. Repeat step (c) for the bottom or the right crop handle so that the crop box line is positioned in the middle of the bottom scale bar on the right scale bar depending upon whether the image was rotated so that the scale appears at the bottom or the side of the image.
3. Once the crop box accurately marks the segment to be used for calibrating the image, press the Enter key to complete the crop process, or click the right mouse button and choose the Crop option, or choose the Crop option from the Image menu. (Photoshop almost always has multiple options for performing each task.)
4. Please note whether (a) the scale in the image is a metric or inch scale, and (b) whether the cropped scale appears vertically or horizontally.
5. From the Image menu, choose Image Size. The Image Size dialog box will appear, as shown earlier in Fig. 11.15.
6. Verify that Resample Image is disabled (the checkbox must be empty) as shown earlier in Fig. 11.15.
7. If the scale appears vertically in the image window, type the length of the segment in the Height text box. Also select the appropriate type of scale for this measurement (Centimeters, Inches, or Millimeters). *Do not change the default resolution value PPI* as Photoshop *automatically* converts the resolution value to PPI regardless of whether the width and height measurements are inches or metric.
8. Mentally record or highlight the value now displayed in the Resolution field and copy (Ctrl plus C; *or* with the cursor over the resolution value, click the right mouse button and choose Copy from the list of options) that value.
9. Press the Esc (Escape) key on the upper-left corner of the keyboard *or* click on the Cancel button in the Image Size dialog box to close the Image Size dialog box.
10. Press and hold the Ctrl key and the Alt key simultaneously, and type the letter "Z" to step backwards and undo the cropping so that the entire image is once again visible. (It may be necessary to press Ctrl plus 0 to make the entire image visible on the screen if the image was zoomed during the calibration process.)
    Note: If the OK button in the Image Size dialog box were clicked in step 9, type the letter "Z" twice while pressing and holding the Ctrl key and the Alt key to display the full image.
11. From the Image menu, choose Image Size again.
12. Again verify that the Resample Image check box is disabled (a checkmark should not appear in the Resample Image checkbox as shown earlier in Fig. 11.15), so that the Width, Height, and Resolution fields are linked.
    Note: It is not necessary to change the unit of measurement for Width and/or Height even if the unit of measurement was changed earlier in this process.
13. Highlight the value now displayed in the Resolution field text box and paste (Ctrl plus V), *or* click the right mouse button and choose Paste from the list of options, *or* type the number noted in Step 8 above. The Height and Width values will change automatically to correspond to the new Resolution (PPI).
14. Click the OK button to close the dialog box.

The digital image is now calibrated, and can be printed at its life-size (1:1) scale, used for comparison.

As stated earlier, this is the preferred method for calibrating larger objects such as palm prints and especially for footwear impressions and tire marks. In addition, the Ruler type does not have to be changed and there is no concern about the "Use Measurement Scale" option creating problems. So this may even be considered a more reliable method for smaller objects, too.

Evaluating the Color Information in Digital Images

After a digital image is calibrated, the next step in the imaging process is to evaluate the color information contained within the image. Depending upon the type of evidentiary image being processed, the only thing that may need to be done is use Auto Tone, Auto Contrast, or Auto Color to balance the color values within the image. Other images may have color backgrounds (noise) that interfere with the visualization of relevant detail in the image and require the use of techniques to suppress the background.

USING CAMERA RAW

SWGIT recommends that Category 2 images be captured using a noncompressed file format such as RAW or TIF. However, very few digital cameras today offer a TIF file format because of the space required on the media for storing noncompressed images as well as the time required to write large files to the camera's storage media (for TIF files, each

pixel in the file requires a minimum of 3 bytes: 1 byte of data each for Red, Green, and Blue.) The data for a camera RAW file can be written in about a third of the time and requires a third of the space required for a standard TIF file because processing of pixel values is deferred until the file is opened on the computer and only brightness values are stored for each pixel.

In addition to being unprocessed and noncompressed, the data are stored exactly as it came from the imaging sensor. The RAW data also contains all the camera settings so that those settings can be applied when the file is opened and the data converted to image pixel values.

Camera manufacturers who sell digital cameras that include a proprietary RAW format option and proprietary software that can be used to open the RAW data file and create a separate TIF or JPG image file. Unfortunately, not all RAW converters store post-camera processing data (ie, changes made during the conversion process).

Conversely, Adobe Photoshop records all changes made during the conversion of the RAW data and stores those changes in the file metadata as shown in Fig. 11.21.

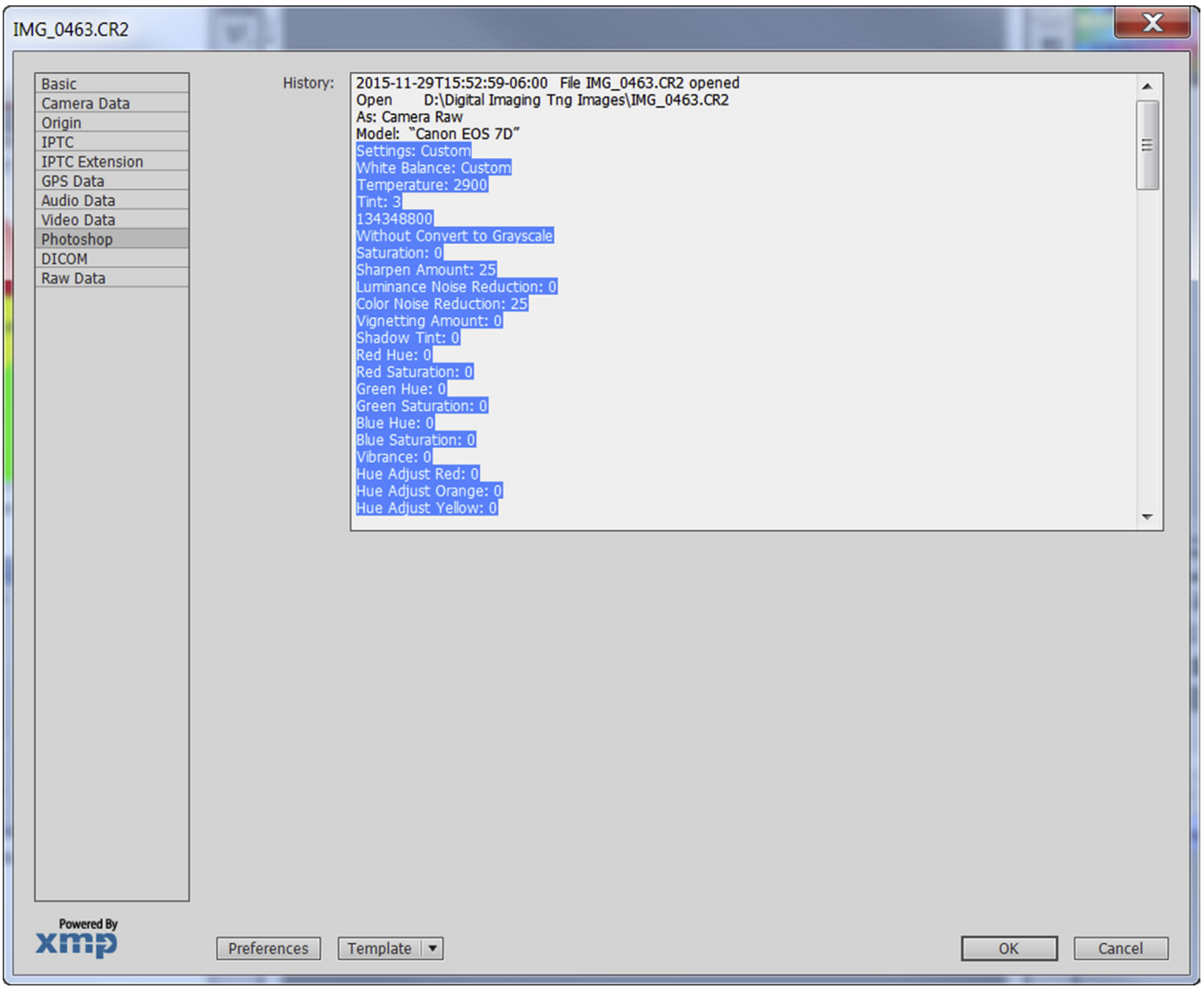


FIGURE 11.21
When propriety camera RAW images are converted in the Adobe Camera Raw Converter, a list of every setting and parameter that can be adjusted in the image is recorded in the digital image file metadata, and can be viewed using the File Info dialog box.

RULE OF THUMB 11.17

One of the most important and accurate methods for ensuring color accuracy when converting camera RAW images is to include an ABFO Forensic grayscale ruler or a forensic ABFO ruler that includes an 18% grayscale value with the object when it is photographed.

To ensure color accuracy as well as optimize the results of digital image processing, SOPs for forensic labs should state that an ABFO ruler (see Fig. 11.22) is required for photographing any image that is or could possibly be of evidentiary value, especially autopsy photographs, photographs of evidence possibly bearing latent ridge detail, photographs of evidence possibly bearing body fluids, photographs of evidence possibly bearing footprint impressions, photographs of evidence that has been processed using chemicals or dye stains, and photographs of evidence captured using an alternate light source, and so forth. In fact, it is recommended that forensic labs should *require* an ABFO Photomacrographic scale for photographing every image that is or could possibly be of evidentiary value.

When a camera RAW file is opened in Adobe Photoshop, the Camera RAW conversion window is displayed as shown in Fig. 11.23.

With the image open in Adobe Photoshop in the camera RAW converter window, select the white balance tool, which is the third tool from the left on the toolbar at the top of the window shown in Fig. 11.23. Then click on the grayscale ruler or grayscale value on the ruler. (If no grayscale ruler is available, click on a value that is a "neutral" color value. This can be an area that appears to be a shade of gray. If the area is too bright, such as an area that is over exposed, the message "The clicked area is too bright to set the white balance. Please click on a less bright neutral area" will be displayed. Click on another area to set the white balance. Multiple areas can be tested by clicking on different areas within the image.) Fig. 11.24 shows before and after correcting white balance.

In addition to setting the white balance, other elements of the image can be adjusted including, but not limited to, exposure, contrast, highlights, shadows, whites, black, clarity, vibrance, and saturation. (While these elements can be adjusted in the Camera RAW window, it is recommended that these elements be adjusted after the image has been converted and opened inside Adobe Photoshop where more control can be exercised over the tool/procedure used.)

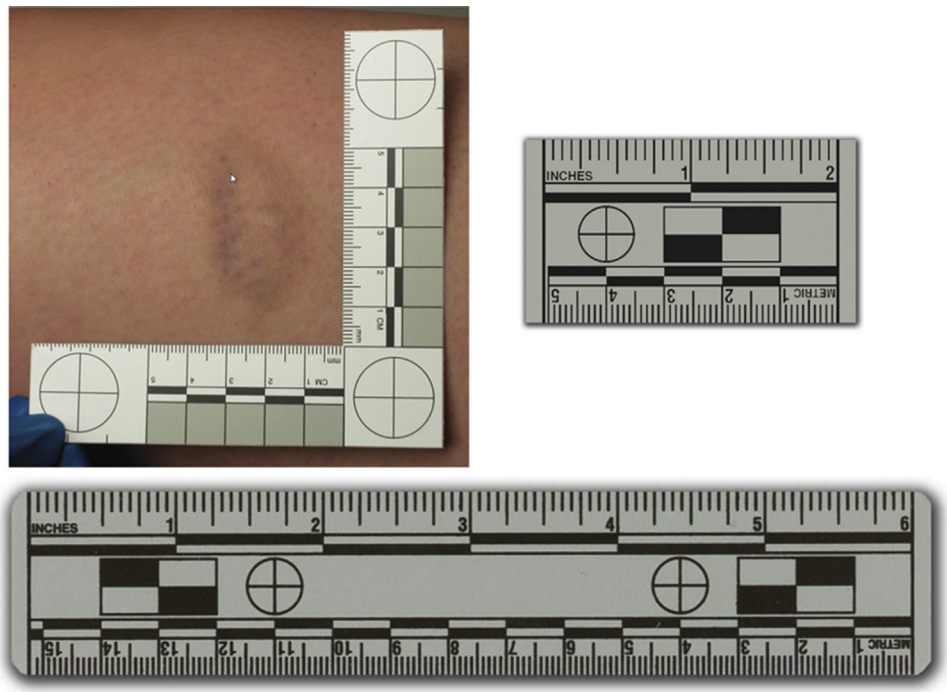


FIGURE 11.22

One of the most important things that one can do when photographing an item digitally is to include an ABFO grayscale ruler in the digital image. The grayscale ruler provides the most accurate and reliable way to adjust white balance in the Adobe Camera Raw Converter window.

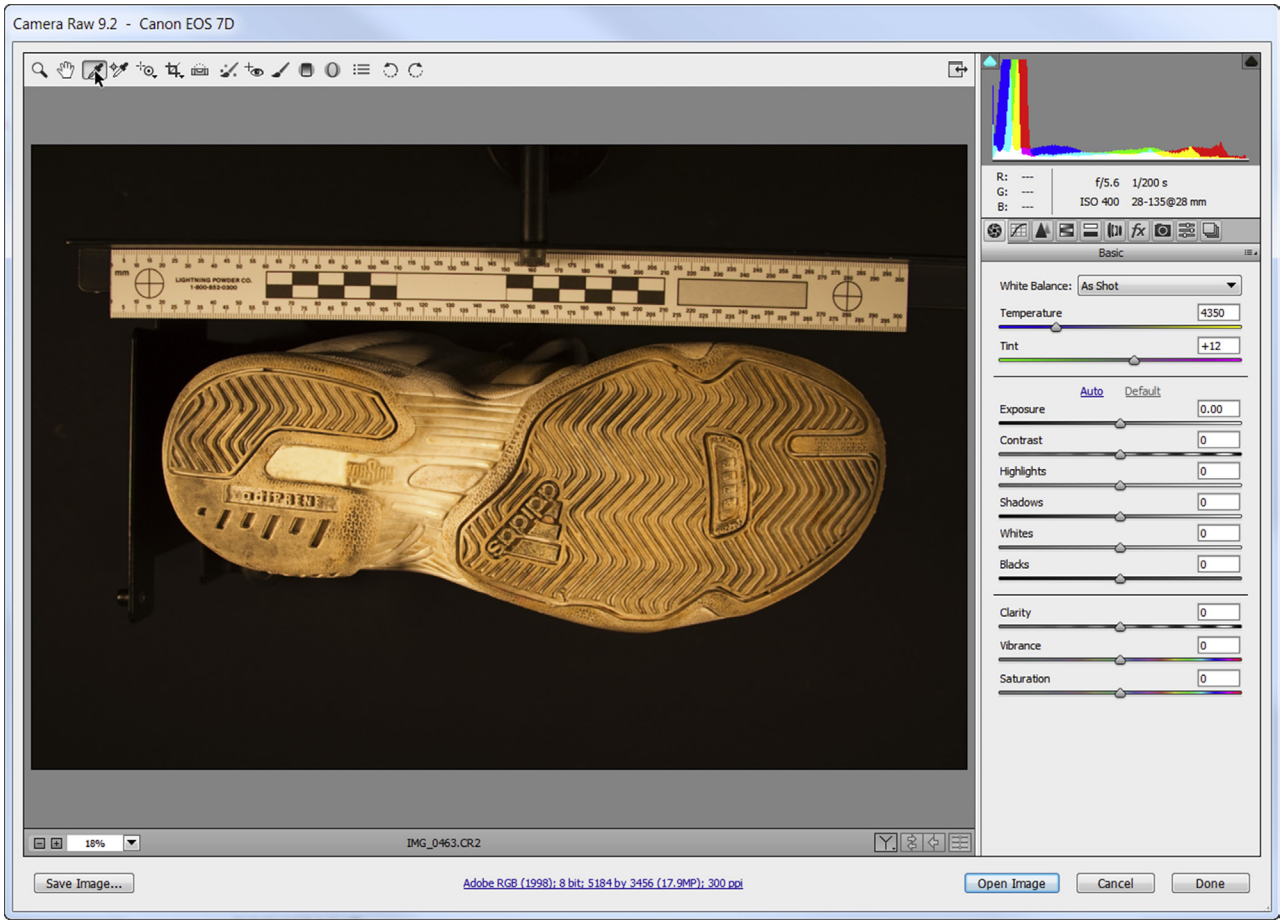


FIGURE 11.23
Using the White Balance tool from the tool bar in the Adobe Camera Raw Converter window, the while balance can be corrected by clicking on the grayscale value on the scale.

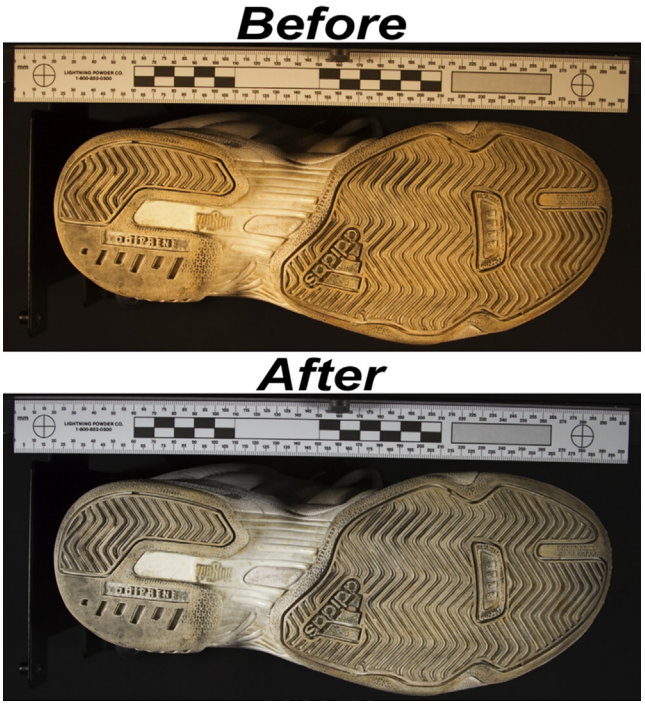


FIGURE 11.24
The difference between images in which the white balance has been corrected is very apparent. This can also make the difference between being able to successfully enhance a digital image and not being able to successfully enhance a digital image.

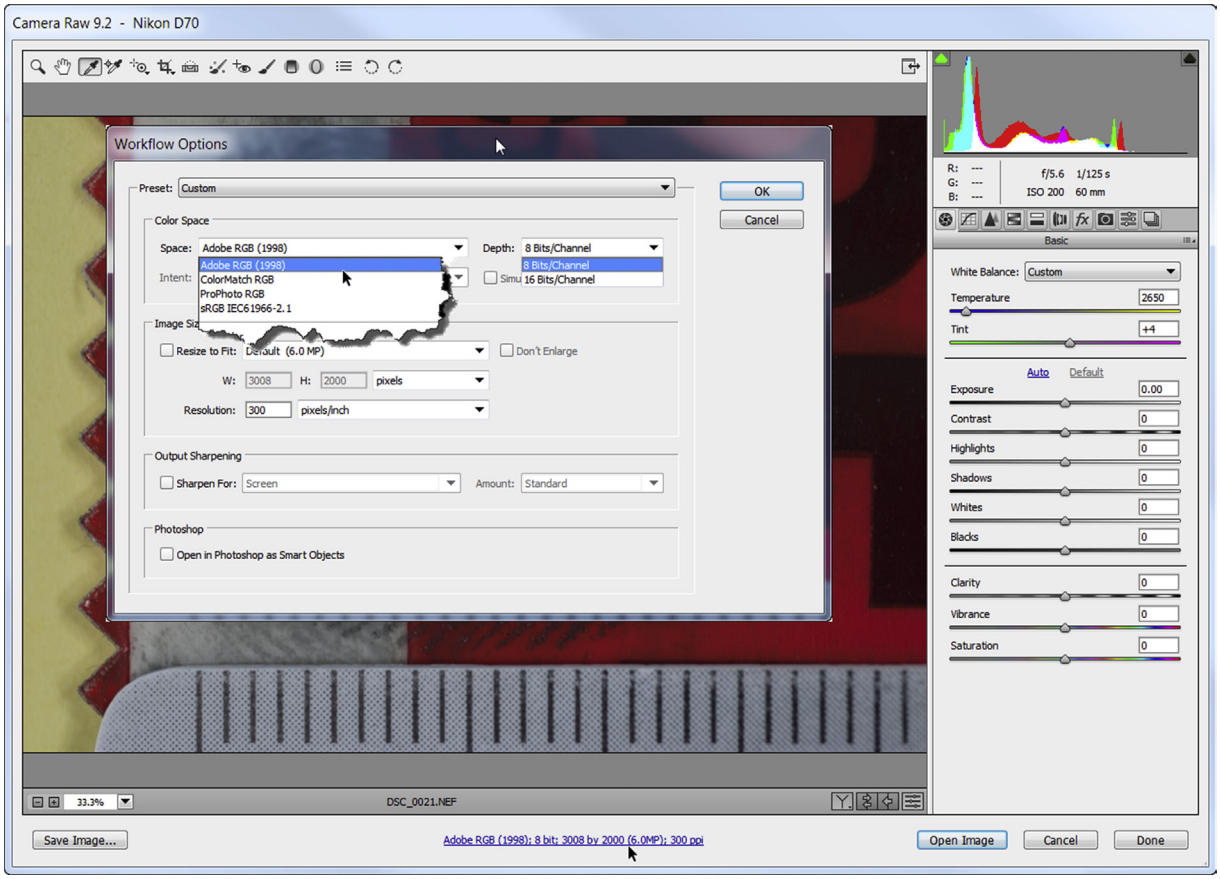


FIGURE 11.25
In addition to adjusting white balance, the Workflow options in the Adobe Camera Raw Converter window provide the ability to set color Space and color bit Depth.

To change image settings, such as bit depth and Color Space, click on the workflow values shown at the bottom of the Camera RAW window as underlined blue text. The workflow options will be displayed as shown in Fig. 11.25.

In the Workflow Options dialog box under Color Space, select the desired Space for the RAW image: select either Adobe RGB (1998) (preferred) or sRGB IEC1962–2.1 as these are the most "standard" options (ie, most monitors and printers have an Adobe RGB (1998) color space profile, and or sRGB IEC1962–2.1 color space profile) and the color values should appear consistent on all platforms throughout the entire imaging process (including display and print).

The digital camera's 12- or 14-bit depth must be converted to either 8- or 16-bit color value, which is set in the Workflow dialog box. When images are converted to 8 bits per color channel (24-bit color), the dynamic color range values above the first 8 bits are truncated at the expense of lighter color values (also known as highlights). Conversely, for images converted to 16 bits per color channel (48-bit color), the full dynamic range is preserved, however, the converted file requires twice the storage space. (When 12- or 14-bit RAW images are converted to 16-bit image files, the missing bits are padded using null values.)

There are pros and cons to both options, but the easiest way to decide which option to select is to choose 8 Bits per Channel if the image is not a complex image and it will not require a great deal of processing; choose 16 Bits per Channel if the image is complex image and will require additional processing.

RULE OF THUMB 11.18

The easiest way to decide between using 8- and 16-bit depth during camera RAW conversion is to choose 8 Bits per Channel if the image is not a complex image and it will not require a great deal of processing; choose 16 Bits per Channel if the image is a complex image and will require additional processing.

Note: Image resolution can also be changed in the Workflow dialog box, however, do not change this value as actual pixel values will be discarded or additional pixel values will be added to the image. Moreover, digital images that will be used for analysis must be calibrated for accurate, life-size scale. Even if the image does not require that it be calibrated, the image size and resolution must be set in the Image Size dialog box for the appropriate output size. In addition, most images have to be cropped because the aspect ratio of most imaging sensors is based on computer screen display settings rather than photograph print sizes.

PROCESSING RGB COLOR VALUES

After the image has been calibrated successfully, the color values must be evaluated to suppress backgrounds or other "noise" that interferes with the visualization (and analysis) of the detail in the image. In some instances it may be necessary to suppress one or more color values, while in other instances it may be necessary to adjust the hue or saturation of one or more color values to match the background so that the foreground detail can be visualized more clearly. In other words, not all images require the same processing techniques. In Fig. 11.26, the image in the upper left needs the red background to be suppressed to so that the ridge detail can be viewed and processed more accurately as shown in the image in the lower left. The image in the upper right corner requires that the red background be adjusted to match the background lettering, so there is a distinguishable difference between the ridge detail and the background as shown in the image in the lower right.

In the image on the left, the Red filter was used to suppress the red color values; in the image on the right, the Blue channel was selected so the red color values appear as a dark grayscale (shadows) value.

Color channels in RGB mode are like using traditional color filters affixed to a lens when photographing black and white images:

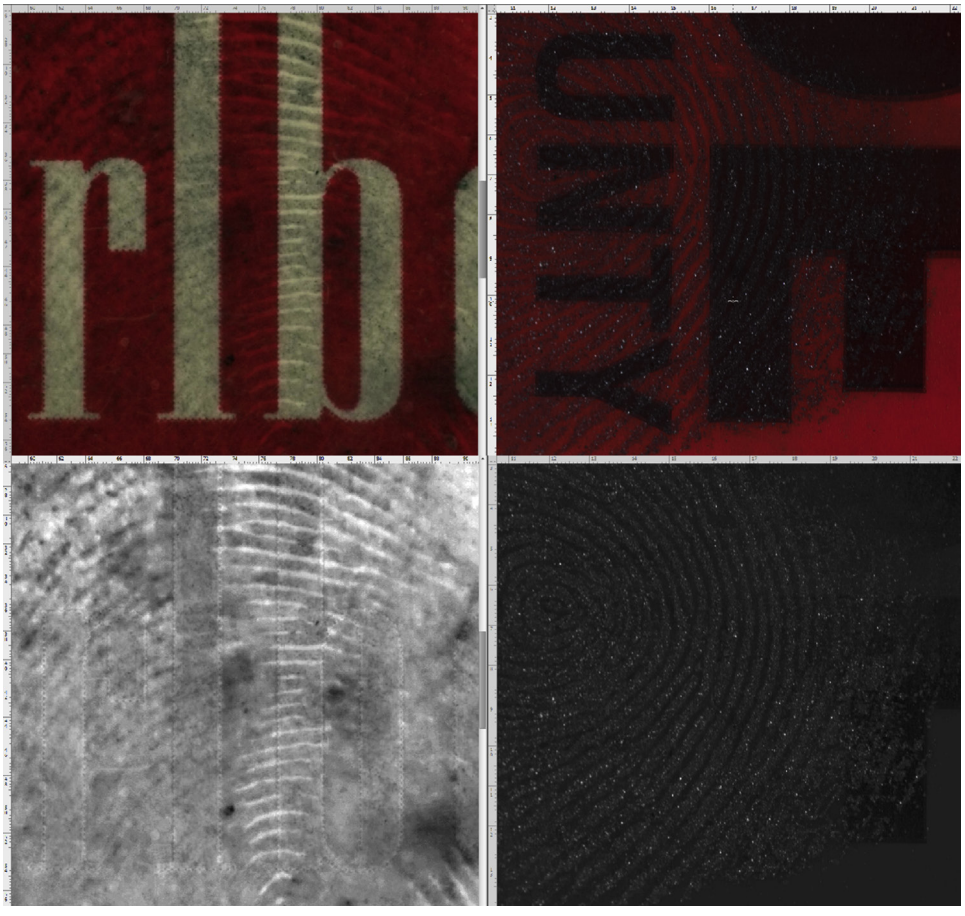


FIGURE 11.26
During the image enhancement process, different color processing techniques are frequently required even when the backgrounds are the same color. Sometimes the color value needs to be suppressed, while in other instances, the background color needs to be viewed using a color channel that makes the background a much darker color value so that it blends with the rest of the background in the image.

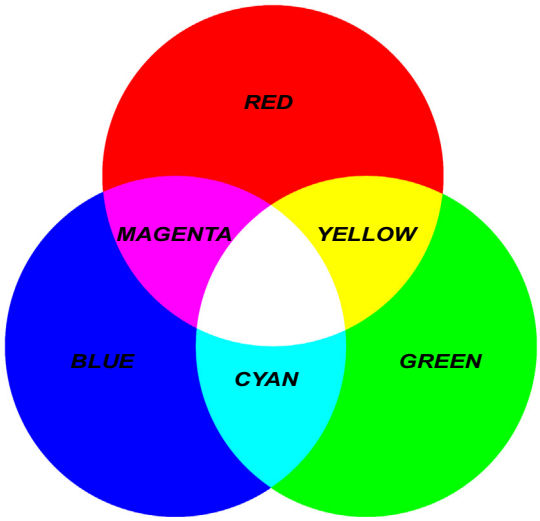


FIGURE 11.27
In digital imaging, all color values are based upon the use of Red, Green, and Blue color values. All digital cameras, flatbed scanners, video cameras, televisions, and computer monitors use these RGB values to create a plethora of other color values. In fact, using 8 bits per color channel (aka 24-bit color), a total of 16,777,216 different color values can be created ($256 \times 256 \times 256$).

In the case of the red filter, pixel values with a red hue are passed through as a white (highlights) value; blue and green pixel values are passed as a dark grayscale value based on the intensity (brightness) of the pixels. As shown in Fig. 11.27, the overlapping color values of red plus blue create magenta color values, which are also passed as a light shade of gray (highlights) as are the overlapping color values of red and green, which creates yellow color values, and are also passed as a lighter shades of gray (highlights).

In the case of the green filter, pixel values with a green hue are passed through as a white value; red and blue pixel values are passed as a dark grayscale value based on the intensity of the pixels. The overlapping color values of red and green, which create yellow color values, are also passed as lighter shades of gray as are the overlapping color values of blue and green, which create cyan and are also passed as lighter shades of gray.

In the case of the blue filter, pixel values with a blue hue are passed through as a white value; red and green pixel values are passed as a dark grayscale value based on the intensity of the pixels. The magenta and cyan color values are also passed as a lighter shade of gray.

Moreover, contrary to popular statements found on the Internet, the use of color channels and color filters do *not* remove objects from an image or change the contents of an image as shown in Fig. 11.28. In this illustration, the RGB image in the upper left is the original image. The image in the upper right corner is the image filtered with a red filter; the image in the lower left corner is filtered with a green filter; and the image in the lower right corner is filtered with a blue filter. The boat appears in each of the images, however, the grayscale value used to represent the boat appears different in each channel. The grass and trees in the image appear the lightest in the image filtered using a green filter, and darker when filtered with a red filter or blue filter. Similarly, the blue sky and the bright blue water appear lighter when filtered with the blue filter and darker when filtered with red and green. Further, selecting a single channel that is filtered with a red, green, or blue filter does not change the number of pixels contained in an image; only the file size is changed because instead of using 3 bytes of data for each pixel, only 1 byte of data is used.

RULE OF THUMB 11.19
Contrary to statements found on the Internet, the use of color channels and color filters do not remove objects from an image or change the contents of an image.

There are two additional color processing techniques that can also be used to facilitate the removal of backgrounds based on RGB color values. As shown in Fig. 11.29, Hue and Saturation can be used to make one or more color values respond to a single color channel. In some instances, such as chemically processed prints where the ridge detail



FIGURE 11.28
Color channels provide the same basic function in digital imaging that color filters provided back in the days for Black and White photography. More specifically, the use of color channels provides the ability to view the images in a different light, so to speak, which frequently helps to suppress background noise when trying to analyze a digital image.

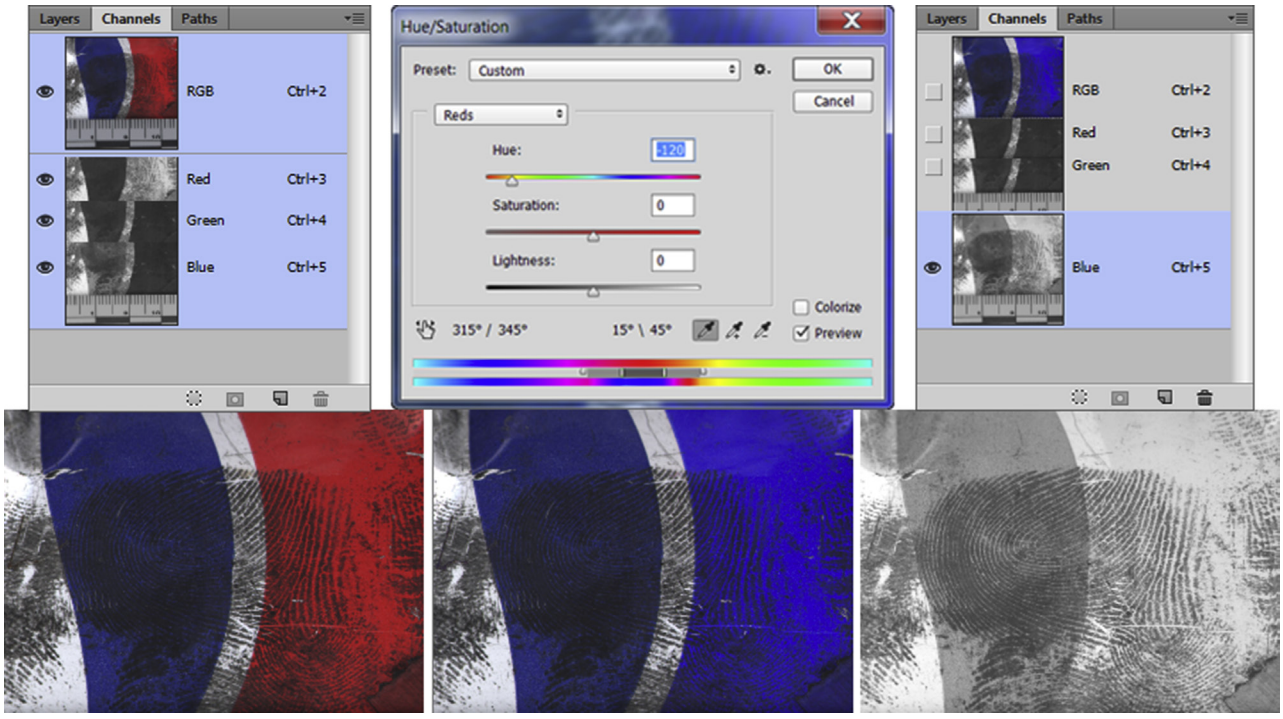


FIGURE 11.29
Using Hue and Saturation, color values can be adjusted so that they respond to a different color filter (channel), thus making it easier to suppress color values when there are two or more color values in an image. (Color channels can only remove one color range at a time, but Hue and Saturation can make that process much more successful and productive.)

appears as a color value that is created through the combination of two colors: for example, a latent print processed with ninhydrin that causes the ridge detail to appear as a magenta color value. In this case, the ridge detail can be processed using the Green color channel in RGB mode, or it can also be processed using the Magenta channel in CMYK (Cyan, Magenta, Yellow, and Black) mode.

ADJUSTING COLOR VALUES USING BLACK AND WHITE

In some instances, an image may contain two or more color values that interfere with the visualization of detail in the image. As discussed above, Hue and Saturation can be used to adjust one or more color values so they can be removed using a single color channel. Another option that is more commonly used to suppress two or more color values in a function called Black and White. The Black and White function provides the added bonus of being able to adjust the contrast for two or more color values in addition to suppressing two or more color values.

Fig. 11.30 shows the results of suppressing the Red and Blue values as well as decreasing the intensity of the Yellow values. To achieve similar results using RGB and Hue and Saturation, the blue area would have to be selected and the contrast adjusted using Levels. The bottom line is that the Black and White function is a single process that performs multiple functions simultaneously: Hue and Saturation, Color Channels, and Levels.

SUPPRESSING BACKGROUND NOISE USING CALCULATIONS

Each red, green, and blue pixel value in a digital image has a brightness (intensity) value that is unique in each color channel. The *Calculations* function in Adobe Photoshop allows you to use the different brightness values for each pixel to produce a composite value for each pixel. This means you can neutralize background noise by blending one channel intensity for a pixel (such as the brightness value of a pixel in the Red channel) with the Channel intensity (such as the brightness value of the exact same pixel in the Green channel) to suppress background noise.

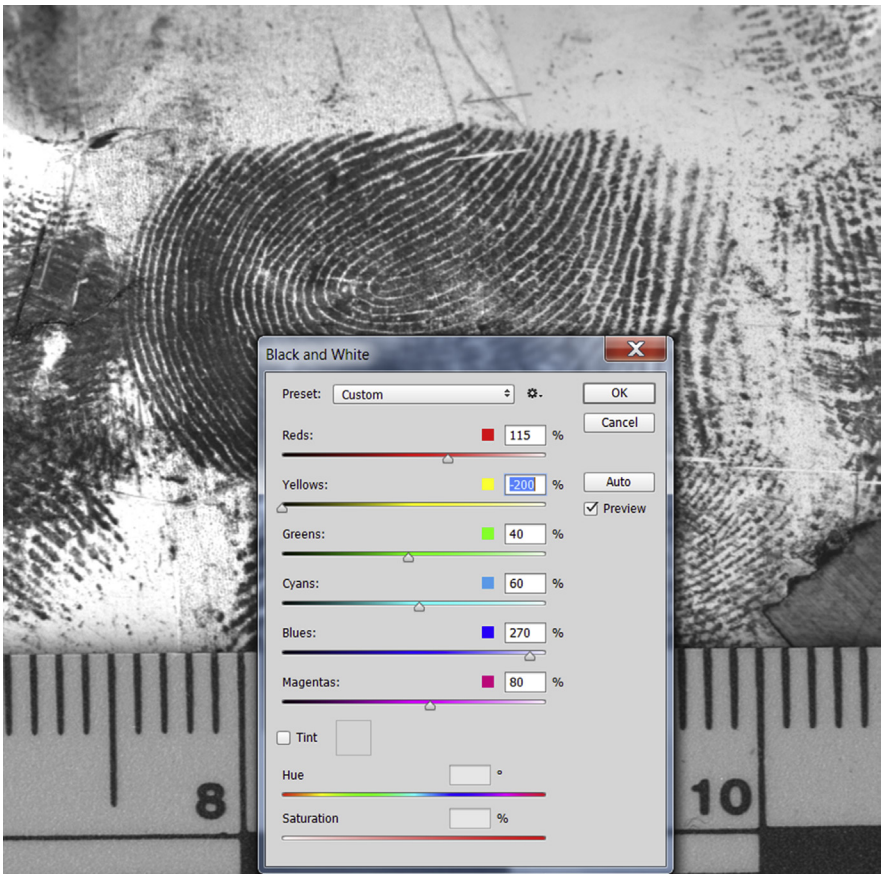


FIGURE 11.30
The Black and White function in Adobe Photoshop provides multiple functionality and can be used to complete multiple digital image-processing steps at the same time. The Black and White option enables the adjustment of hue, saturation, and brightness; at the same time it provides the ability to increase color values (aka signal boost) as well as adjust the tonal range contrast for each color value. As a result, the Black and White function in Adobe Photoshop has become one of the most commonly used tools in the area of forensic digital processing of evidentiary photography.

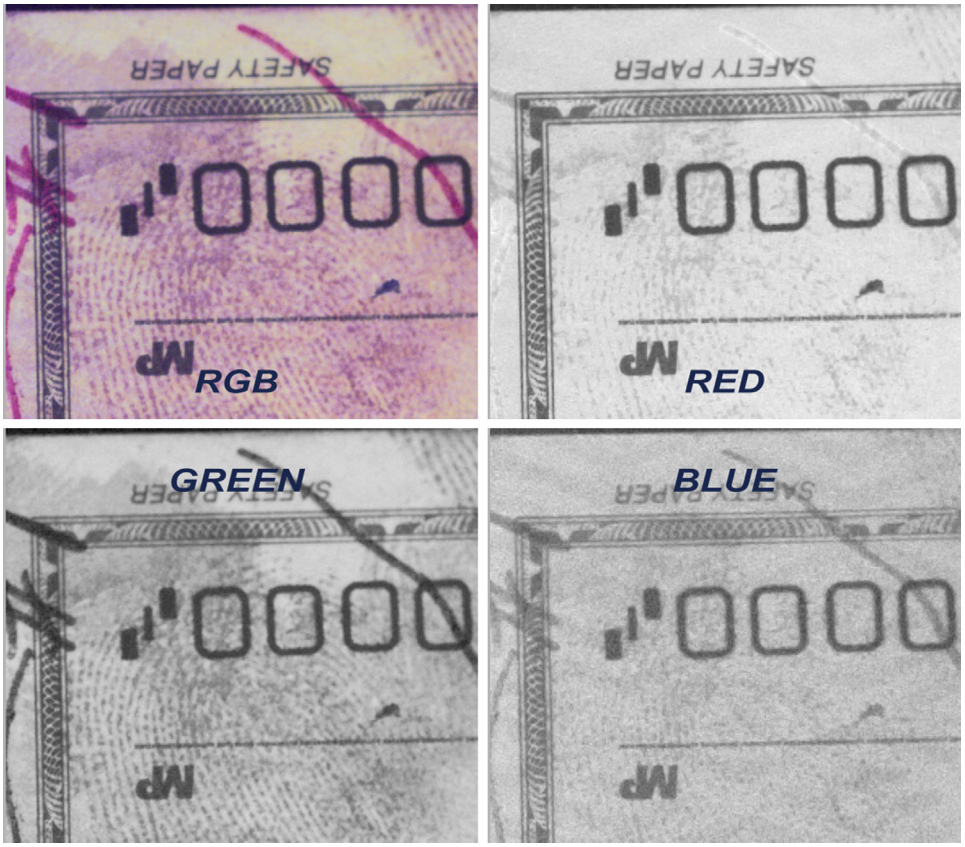


FIGURE 11.31
The Red, Green, and Blue color channels also provide the ability to isolate elements in a digital image, which can be used with processes such as Calculations to suppress background noise that interferes with the visualization and analysis of the content in the image.

For example, Fig. 11.31 shows the difference in brightness values for a ninhydrin print on a check. The image appearing in the upper left shows the original image in RGB color. The image in the upper right shows the image filtered with the Red channel; the image in the lower left shows the image filtered with the Green channel; and the image in the lower right shows the same image filtered with the Blue channel.

The appearance of fingerprint ridge detail is less visible in the Red channel while they appear darker in the Green channel. In addition, the intensity of the check border in the Red channel is almost identical to the intensity of the border in the Green channel. In the Blue channel, the ridge detail blends into the background and the border also appears to be a lighter shade of gray. In addition, there is more background noise in the Blue channel than in either the Red channel or the Green channel.

Due to the similarity of the background in the Red and Green channels, and because the ridge detail is more visible in the Green channel, it is possible to subtract the values of the Red from the Green channel using an algorithm that simulates mathematical equations or *Calculations*. However, there is more to the process than simple subtraction. For example, we do not want to subtract the subtle ridge values in channel Red from channel Green because the ridge detail is already a light grayscale value and the contrast will have to be increased. To suppress the background without affecting the ridge detail:

1. Open the image to be processed.
2. Calibrate the image.
3. From the Image menu, choose Calculations. The Calculations dialog box will appear, as shown in Fig. 11.32. (*Note*: The Calculations dialog box shown in Fig. 11.32 has already been completed with the before and after pictures in the background.)
4. In Source 1, choose the Red channel. (This channel contains the background to be neutralized.)
5. Also in Source 1, click on the Invert box to the right of the Channel list box. (Step 7 explains why.)

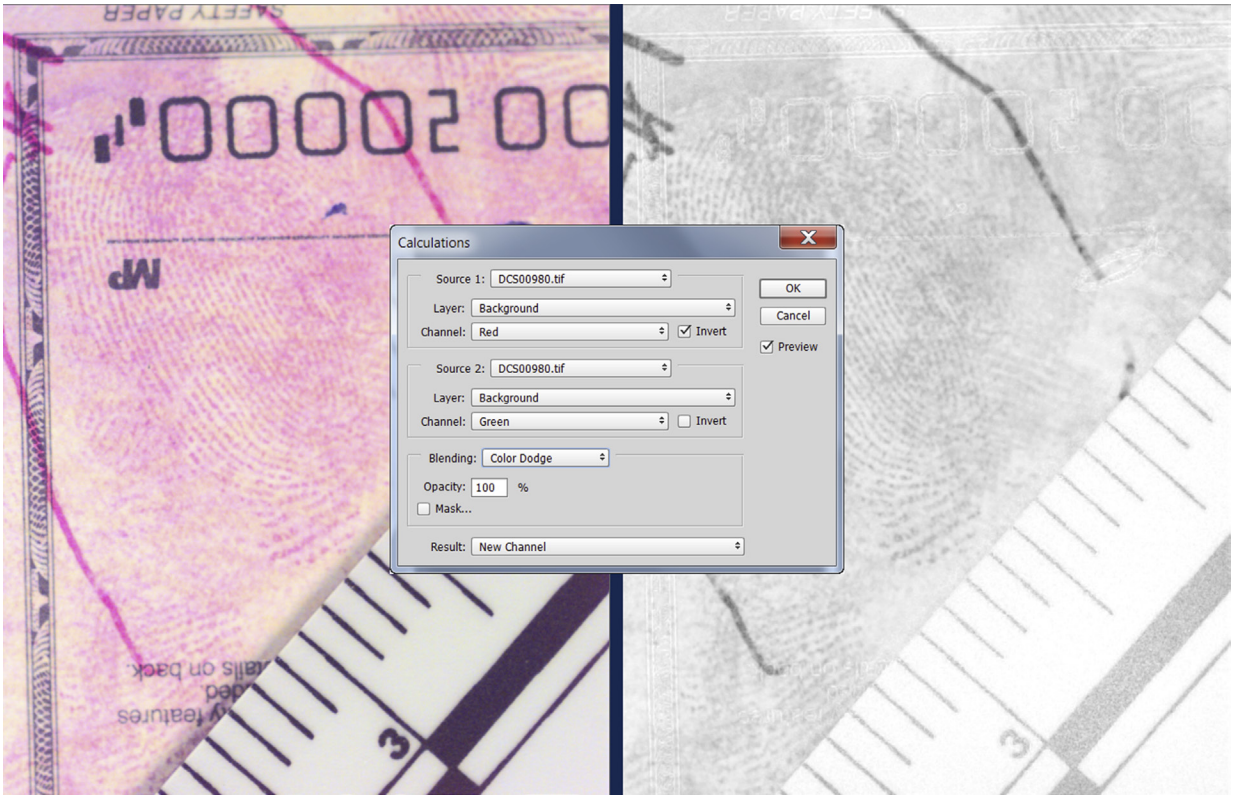


FIGURE 11.32
One of the common techniques for suppressing background noise in a ninhydrin print is to use the Red channel as Source 1, which is also inverted, and the Green channel as Source 2 together with the blending option Color Dodge or Linear Dodge.

6. In Source 2, choose the Green channel. (This channel contains the background that you want to neutralize and it also contains the ridge detail that you want to preserve.)
7. From the Blending drop-down list, choose Color Dodge.
   Note: The algorithm (mathematical calculation used for the pixel values) for this process compares the pixel value in Source 2 to each pixel's corresponding value in the inverted Source 1. More specifically, when the dark values of the border pixels in the Red channel (shown on left in Fig. 11.33) are inverted, they appear as a lighter shade of gray (as shown on the right in Fig. 11.33). In the case of a latent impression, the ridge detail is practically nonexistent on the Red channel, so the pixel values for the background and whatever ridge detail is present is inverted from white to black on the histogram. And, since the Color Dodge function only *reduces* Source 2 pixel values, the ridge details and background in the green channel are lighter shades of gray (on the white side of the histogram), so no action occurs because the corresponding pixel values for that area on the Red channel are all on the dark (left) side of the histogram.
8. The darker values can also be reduced to match the lighter values by adjusting the Opacity. (Usually, if the black values become too light, similar to being overexposed, you can reduce the Opacity to match the rest of the background in the image.)
9. Click the OK button to close the dialog box.
   A new Alpha 1 channel (also referred to as a multichannel value because it consists of the processed brightness pixel values from two channels: Source 1 and Source 2) will appear on the color Channels palette, as shown in Fig. 11.34.
10. With Channel Alpha 1 highlighted on the Channels palette, from the Image menu, choose Mode and then choose Grayscale to discard the unused channels.
    Any time a new Alpha channel is created in a digital image, the Alpha channel must be converted to grayscale because other applications do not recognize multichannel values; if the image is saved with RGB channels and the Alpha channel, the image will appear as the RGB image outside Adobe Photoshop, and the processed results will not be visible. To fix this problem, simply open Adobe Photoshop, select the Alpha channel, convert the image to grayscale, and resave the image.

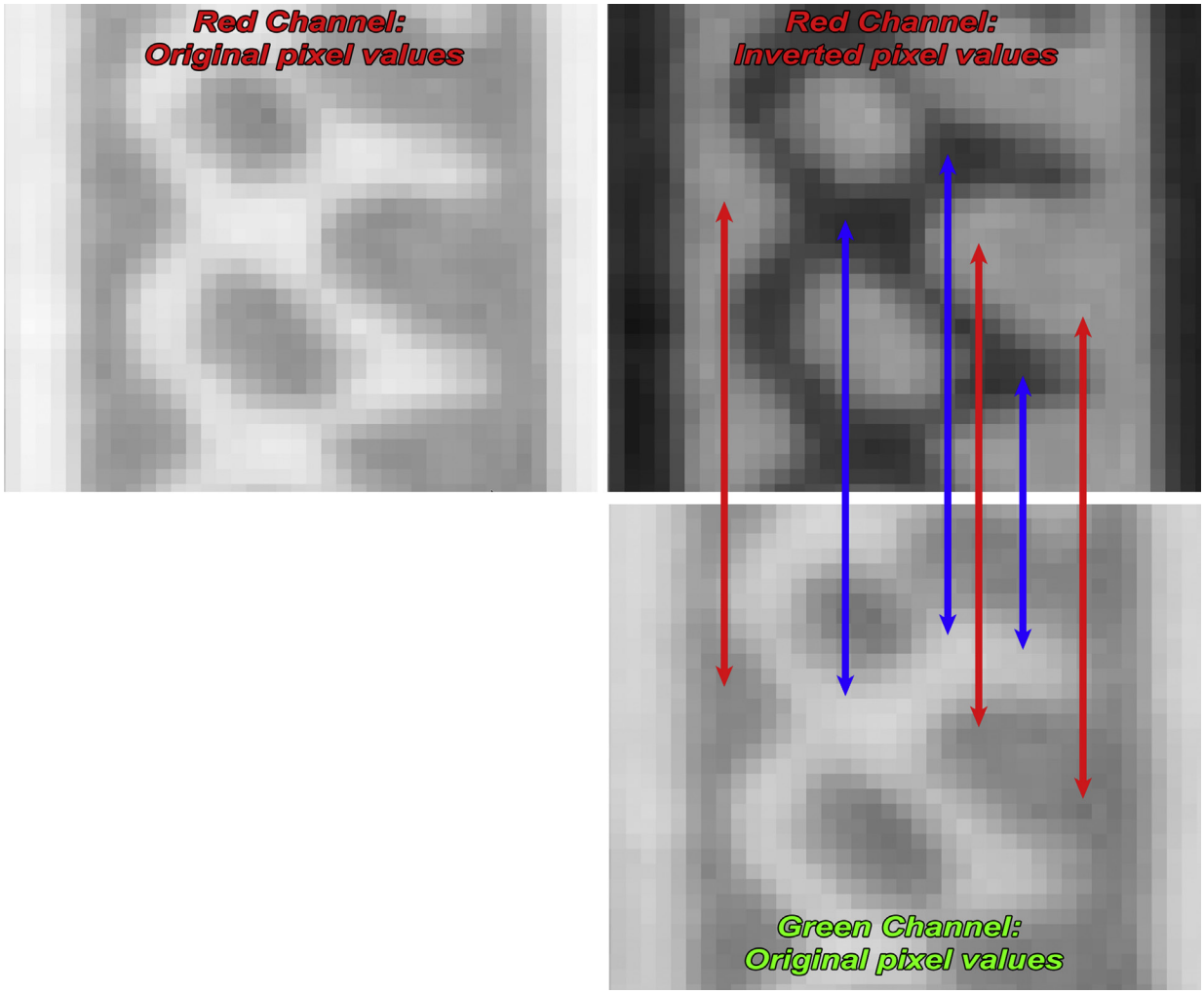


FIGURE 11.33
The dark pixel values in the Green channel are compared to the corresponding pixel values in the Red channel (*red lines*). If the pixel value in the green channel is darker than the corresponding pixel value in the Red channel (ie, the green pixel value would appear to the left of the corresponding red pixel on a histogram), the Green pixel value (Source 2) is reduced to the Red pixel value (Source 1). The algorithm also compares the light pixel values in the Green channel with the corresponding pixel values in the Red channel (*blue lines*). If the pixel value in the green channel is darker than the corresponding pixel value in the Red channel (ie, the green pixel value would appear to the left of the corresponding red pixel on a histogram), the Green pixel value (Source 2) is reduced to the Red pixel value (Source 1). However, if the pixel value in the green channel is lighter than its corresponding value in the Red channel (ie, the green pixel value would appear to the right of the corresponding red pixel on a histogram), no change is made to the Green pixel value.

Although Adobe Photoshop provides a number of blending options, the most commonly used blending techniques are:

- Multiply: This blending technique compares the brightness value of the pixels in each channel and multiplies the pixel value in Source 2 by the brightness value of the same pixel in Source 1. (The result is generally a darker contrast because multiplying a darker value with another dark value produces a darker result. Multiplying a lighter value with another light value basically leaves the brightness value unchanged.)
- Linear Dodge: This blending technique behaves in much the same way as Color Dodge. However, with Linear Dodge, the dark values are suppressed even more than in Color Dodge, which is sometimes required because of the background contrast. Typically in this case, the Opacity must also be adjusted because the additional background suppression makes it appear as though it were overexposed. Opacity adjusts the exposure for these areas.
- Screen: This blending technique compares the color information in each channel and multiplies the inverse of the Source 1 and Source 2 brightness values to create a result that is always a lighter contrast.
- Overlay: This blending technique multiplies or screens the brightness values depending on the brightness value in Source 2 while preserving the highlights and shadows of Source 2. The brightness values of the pixels of Source 2 are not replaced but rather are blended with the brightness values of Source 1 to provide more contrast between light and dark values.

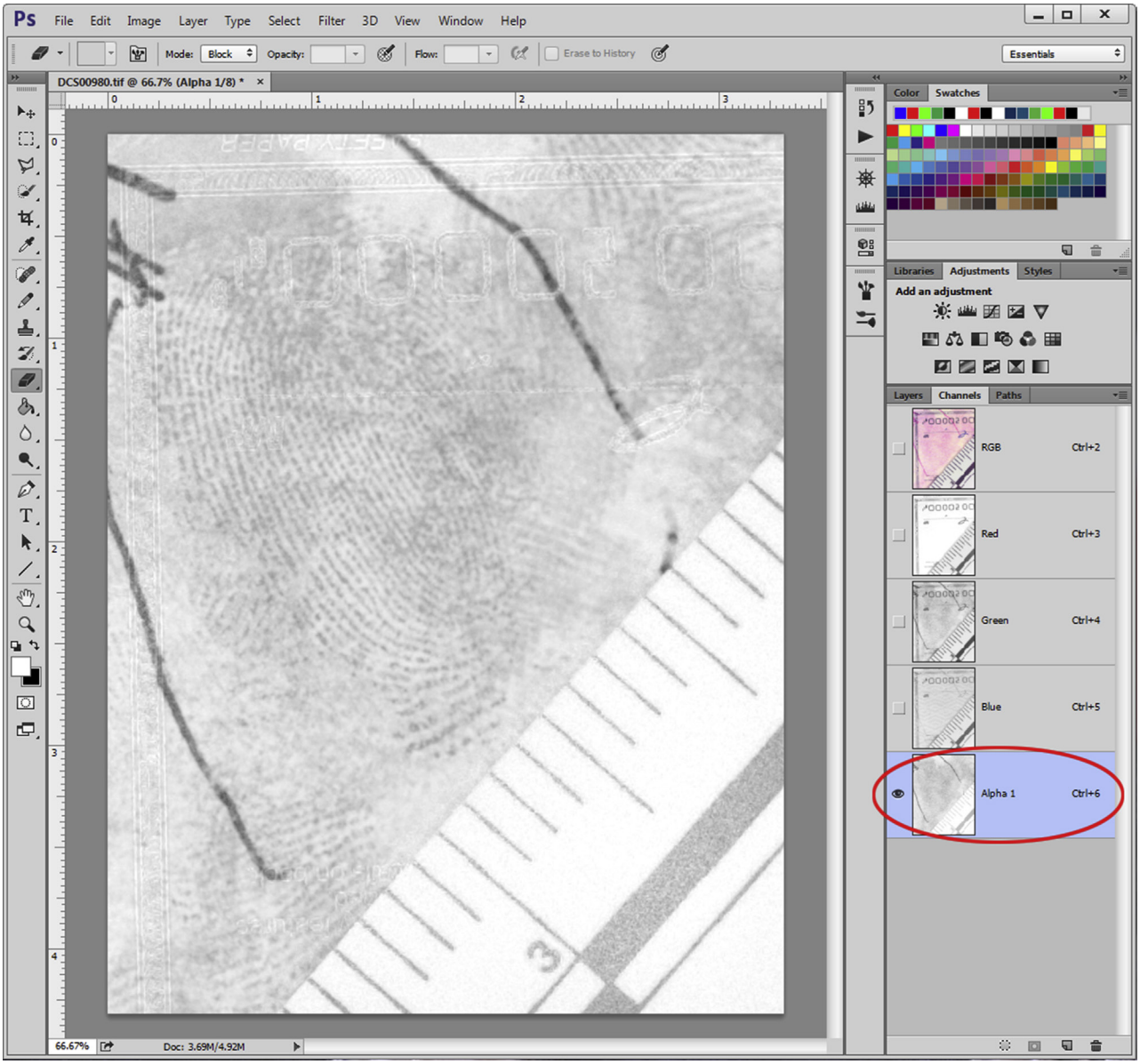


FIGURE 11.34
Calculations creates a single color channel based on the combined color values of two separate color channels. This single color channel is commonly referred to as an Alpha channel. The first multichannel value is labeled Alpha 1, the second multichannel value is labeled Alpha 2, and so forth. The channel values of two Alpha channels can also be combined to form yet another Alpha channel.

USING MODE > LAB COLOR

While the Calculations feature is very useful, this process does not work in all instances as it depends on the intensity values for two channels in the image. This process does not typically work well for digital images captured using a flatbed scanner because the intensity (brightness) value for pixels in the Red channel and Green channel are too similar. (Flatbed scanners have only one light source, so the same light intensity is used for capturing red, green, and blue pixel values.) Similarly, images photographed digitally using an alternate light source have brightness values that are far too similar in all color channels.

In addition, all digital cameras (except digital SLR cameras that use a Foveon imaging sensor) have a color filter array (CFA) consisting of red, green, and blue filters overlaying the imaging sensor in the camera. In most, if not all, instances, the CFA consists of 50% green filters, 25% red filters, and 25% blue filters. The camera (or the computer in the case of an RAW image) calculates pixel color values using a demosaicing algorithm commonly referred to as a Bayer pattern that creates the color values using the brightness values and color filtered pixel value from the neighboring photo sensors.

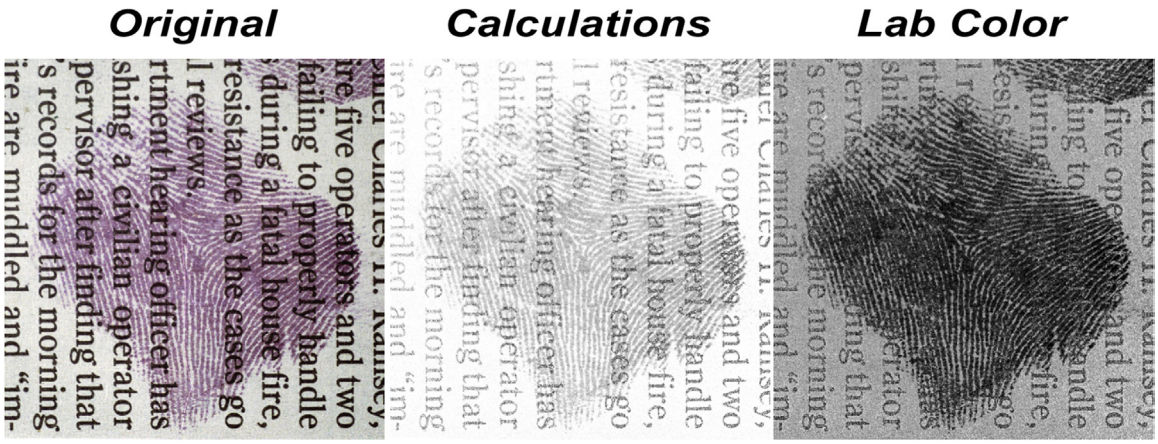


FIGURE 11.35
All color values are not created equal as some lighting techniques have a limited spectrum which causes the intensity values for the Red, Green, and Blue color values in a digital image to be very flat (without much contrast), which requires different color processing techniques.

In these instances, the Calculations process may not provide the desired results. The alternative solution is to use *Lab Color* mode. In Lab Color, the channels are broken down into:

- Lightness channel, which displays the intensity value of all pixels without the color values generated from the CFA.
- Channel a, which displays the chromatic (color) values of all pixels using only the green and red CFA values.
- Channel b which displays the chromatic (color) values of all pixels using only the green and blue CFA values.

(Hence, the mode's name, Lab Color.)

As you can see in Fig. 11.35, Calculations did not work very well developing the ridge detail in a ninhydrin print developed on newspaper that was scanned with a flatbed scanner. However, using Lab Color Channel a, the background printing is suppressed. The full process is as follows:

1. Open the image to be processed.
2. Calibrate the image.
3. From the Image menu, choose Mode and then choose Lab Color.
4. In the Channels palette, click on Channel a. (In this case, the ridge detail appears inverted with light ridges on a dark background due to the intensity of the resulting color values and the background contrast values.)
5. In this case, from the Image menu, choose Adjustments and then choose Invert.
6. From the Image menu, choose Adjustments and then choose Levels. (Since the luminance values (Lightness channel) are separated from the Chrominance values (Channels a and b), Levels is the only process that can be used to spread the Chrominance (midtone) values across the full width of the histogram and thus create contrast between the values.)
7. As shown in Fig. 11.36, adjust the shadows and highlights first; making sure that neither value goes beyond the first grayscale value appearing on the *x*-axis of the histogram for either Shadows or Highlights. Then adjust the midtone values (middle slider) as desired for contrast.
8. Click the OK button to close the dialog box.
9. With Channel a highlighted on the Channels palette, from the Image menu, choose Mode and then choose Grayscale to discard the unused channels.
   Failure to convert an image to grayscale that has been processed using Lab Color will cause the image to appear "unusual" when you reopen the digital image later.

The Lab Color process also works well for digital images captured using a forensic light source. Fig. 11.37 shows a latent print that was developed on the sticky side of duct tape using a dye stain process called Basic Yellow that provides a yellow fluorescence and then photographed using a forensic light source. The digital image was processed using the same steps described earlier, but the image did not have to be inverted because the ridge detail in this image appeared as a positive image (dark ridge detail on a lighter background).

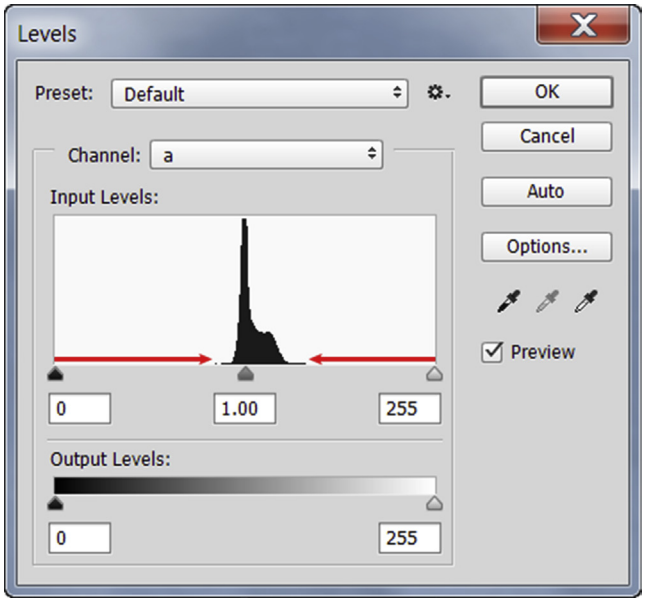


FIGURE 11.36
Converting a digital image to Lab color allows the digital image to be viewed in its most basic components: luminance and chrominance. Using Channel a and Channel b, the chrominance values can be separated into the Green plus Red values (Channel a) and the Green plus Blue values (Channel b). To view the chrominance values, they must be spread out across the full range of 256 color values using Levels.

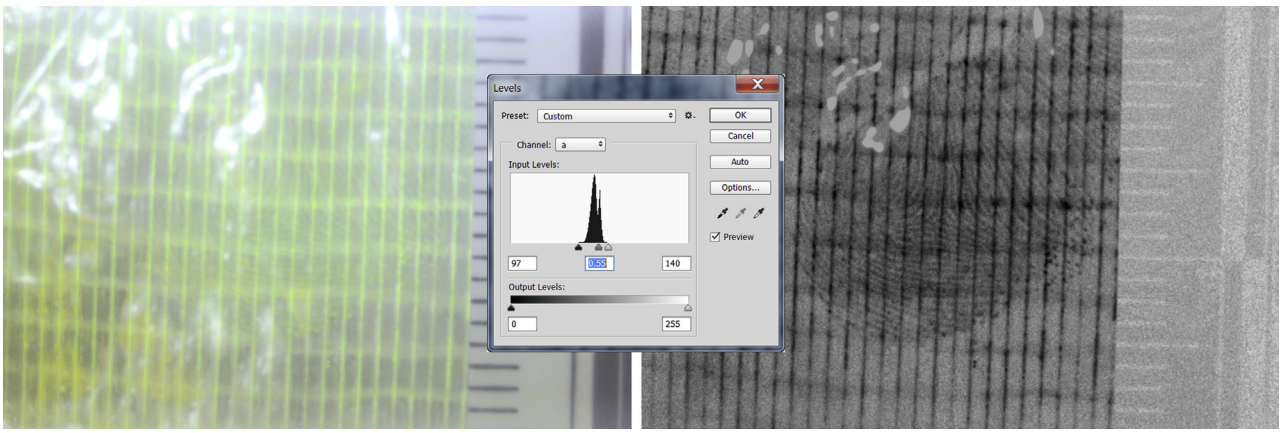


FIGURE 11.37
Lab color can be used very successfully to mitigate the effects of over- and under-exposure and reveal data that is not easily visible by the human eye.

The lines appearing across the image in Fig. 11.37 could also be removed using a tool commonly referred to as a fast Fourier transform (or FFT) filter. As with the automated image calibration utility, you can purchase FFT plug-ins for Adobe Photoshop for this purpose.

Note: While most FFT filters are based on the same technology and ultimately provide similar results, the manner in which they are used varies from one application to another. Moreover, Adobe Photoshop does not include an FFT filter, so a plug-in must be acquired for this purpose. To prevent the loss of image detail using an FFT plug-in, be sure to follow the instructions provided with that specific plug-in.

Adjusting Tonal Range and Contrast

The next step in the imaging process is to adjust tonal range and contrast. This process typically involves the use of tools such as Levels, Shadows/Highlights, and Curves. The Apply Image command can also be helpful to adjust tonal range and contrast as well as increase the contrast after using Levels, Shadows/Highlights, and Curves, and when the image needs a little more contrast. The Multiply blending option in the Apply Image command, commonly referred to as a "signal boost," is very useful for this purpose.

There are also two other functions that can be used to fine-tune tonal range and contrast: (1) Exposure, and (2) Brightness and Contrast. Burn and Dodge can also be used to fine-tune the tonal range and contrast, but Burn and Dodge can also be successfully used to provide additional contrast at any time throughout the process.

While Exposure and Brightness and Contrast functions are fairly self-explanatory and are easy to use with a little practice, tools such as Levels, Shadows/Highlights, Curves, and Burn and Dodge deserve some detailed explanation because these tools, if used improperly, can be destructive and lead to challenges in the courtroom!

ADJUSTING TONAL RANGE AND CONTRAST: LEVELS

One of the most commonly used tools for adjusting tonal range and contrast is Levels. The reason for its popularity is that a relatively high degree of contrast can be achieved quickly and easily by compressing the number of grayscale values by sliding the shadows slider or by sliding the highlights slider as shown in Fig. 11.38. The median between these two points can also be adjusted by sliding the middle slider, also known as the mid-tone or gamma slider bar.

If used improperly, Levels can also be very destructive. Grayscale values are clipped in Levels by moving the shadows slider (the black triangle under the *x*-axis of the histogram) to the right past the first grayscale value on the left side of the histogram. In Fig. 11.39, all of the grayscale values to the left of the Shadows slider—pixels with grayscale values 0 to 138—will be reassigned the value of zero or black. Moreover, the pixels with values of the remaining 117 shades will be reassigned a value between 1 and 255. As a result, the contrast between pixel values in this range will be lost, together with the image detail, resulting in an image with a histogram as shown in Fig. 11.40.

RULE OF THUMB 11.20

If used improperly, Levels can also be very destructive.

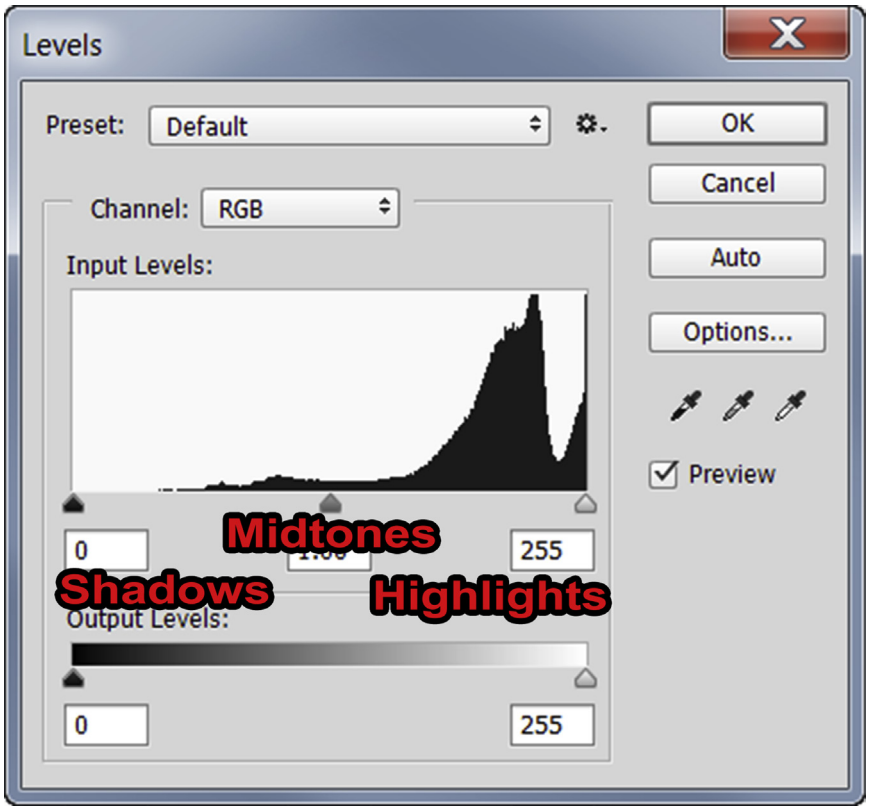


FIGURE 11.38

Levels can be used to adjust the three primary contrast values: shadows, midtones, and highlights. The bad news is that Levels can be a very destructive process if used improperly. But the use of Levels also effects every pixel value that is represented on the histogram. Grayscale values can be condensed and are then redistributed across the full histogram.

To identify pixel values that will be clipped, press and hold the Alt key when moving the shadows value (the black triangle on the left side of the histogram) as well as when moving the highlights value (the white triangle on the right side of the histogram). When moving the shadows slider, pixel values that will be clipped (values that will be reassigned to zero or Black) will appear in the image window as a black value. Similarly, when moving the highlights slider, pixel values that will be clipped (values that will be reassigned to 255 or White) will appear in the image window as a white value. So while the levels tool is a destructive tool, the use of this tool can be monitored to ensure that no pixel values are clipped during the process.

RULE OF THUMB 11.21

To identify pixel values that will be clipped when using Levels, press and hold the Alt key when moving the shadows slider as well as when moving the highlights slider.

ADJUSTING TONAL RANGE AND CONTRAST: SHADOWS/HIGHLIGHTS

Because of the potential for loss of detail with every pixel value being modified when using Levels, Shadows and Highlights is the "preferred method" for balancing tonal range instead of Levels.

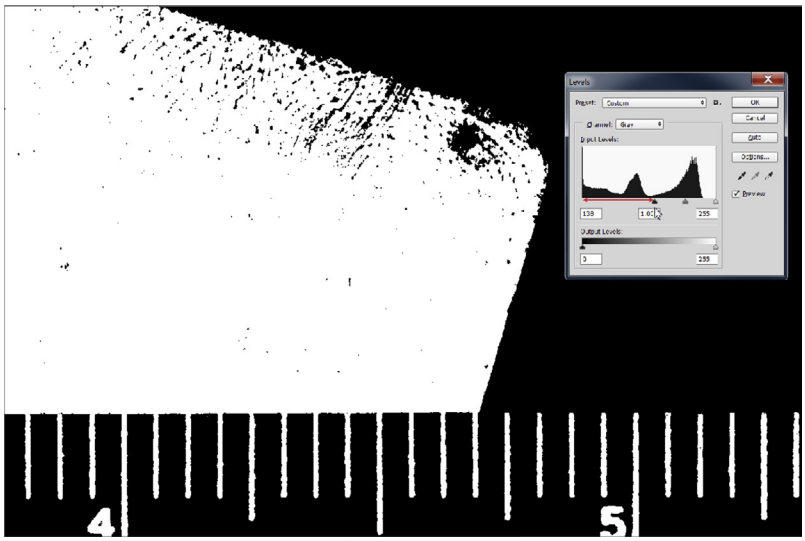


FIGURE 11.39
Pressing and holding the Alt key while moving the slider for Shadows and Highlights along the *x*-axis of the histogram identifies what grayscale values and pixels, if any, will be clipped during the current Levels session.

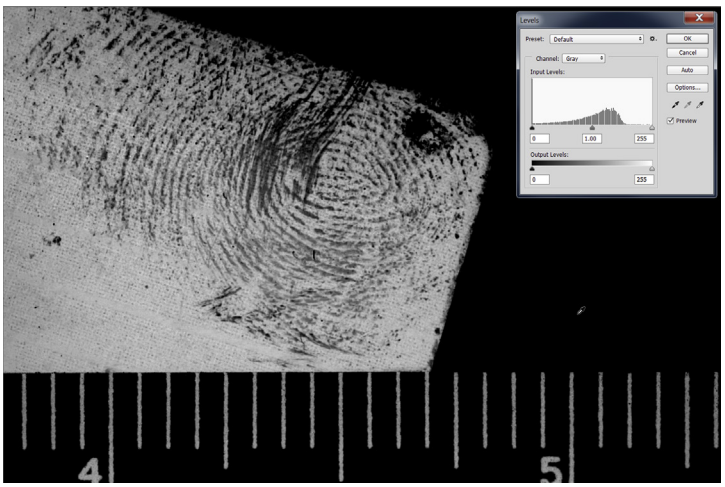


FIGURE 11.40
The effects of the redistribution of grayscale values among the pixels in the image is very visible, and the clipped pixel values are represented by a tall bar on the Shadows end at value 0 or on the Highlights end at value 255.

Note: Shadows and Highlights was first introduced in Adobe Photoshop CS, which was released in October 2003. Before this tool became available, Levels was the most commonly accepted method for adjusting contrast in digital images.

The Shadows/Highlights command provides greater control when adjusting contrast as shown in Fig. 11.41. Using this tool, the adjustment of pixel values can be limited to a very specific range of values in both the shadows and/or highlights. In other words, the contrast can be adjusted for pixels in the Shadows range without affecting the values of pixels in the Highlights range and vice versa. Also, one range of pixel values can be adjusted without affecting all of the other pixel values in the image, which is a *vast improvement* over the use of Levels.

RULE OF THUMB 11.22

The Shadows/Highlights command provides better control than Levels for adjusting contrast.

As shown in Fig. 11.41, the Show More Options box must be enabled (a checkmark must appear in the "Show More Options" checkbox). The Shadows/Highlights command provides separate controls for adjusting Shadows and Highlights independently of one another as well as adjust brightness and midtone contrast of the image.

There are three settings that can be adjusted for Shadows and Highlights:

- Amount: Controls the quantity of contrast to be applied. (Think of a dimmer switch where 0 equals off and 100% is the full level of brightness in the room.)

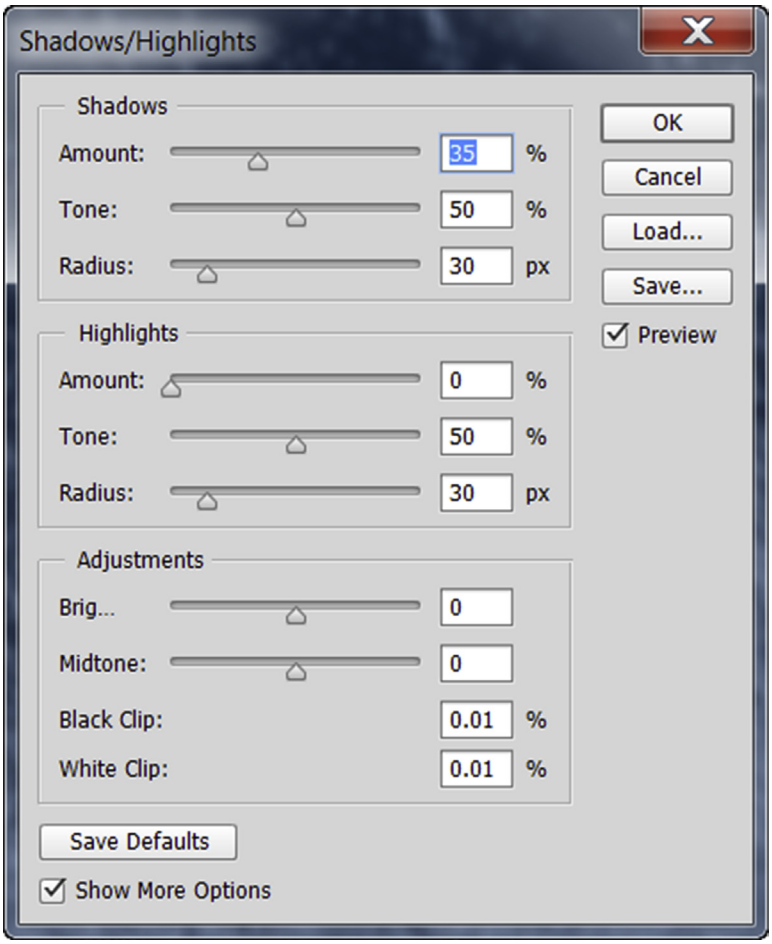


FIGURE 11.41

The Shadows/Highlights function provides a significantly better control in the processing of tonal range and contrast values. In addition, this tool provides the ability to adjust limited grayscale values *without* affecting other grayscale values.

- Tonal Width: Controls the range of values within the shadows or highlights that are modified. For shadows, a lower percent restricts the adjustments to only the darker value; and for highlights, a lower percent restricts the adjustments to only the lighter value. Higher values increase the contrast for pixel values near the midtone range.
  For Shadows in relationship to a histogram, 0 equals black (0 on the histogram) and 100% is the value of 1.0 of the midtone slider. So the only shades of gray that would be adjusted are the specified shades of gray to the right of 0; no other shades of the histogram will be effected.
  For Highlights in relationship to a histogram, 0 equals white (255 on the histogram) and 100% is the value of 1.0 of the midtone slider. So the only shades of gray that would be adjusted is the specified shades of gray to the left of 255; no other shades of the histogram will be effected.
- Radius: Controls how many pixels are considered when comparing the contrast of each pixel to the neighboring pixel values.

ADJUSTING TONAL RANGE AND CONTRAST: CURVES

Within Adobe Photoshop, the Curves tool is one of the most effective and controllable methods for adjusting contrast between two pixel values that are very close to one another on the histogram. It is often the only method that separates details that are very similar in tone. Like Levels, Curves utilizes a histogram function to graph pixel code values. Unlike Levels, the information is presented to the user as a contrast curve with specific pixel values plotted along a diagonal line representing the tonal values from 0 (black) to 255 (white), and the 254 levels of gray in between. To access Curves, click Image, Adjust, and then Curves.

The Curves interface was designed to mimic the characteristic curve for photographic film. When film is processed, changing the time and/or temperature of the film developer can alter the contrast characteristics. Once processed, the image contrast can be plotted on graph paper using a densitometer to read the silver or dye densities in the processed negative. Using a characteristic curve for a particular film and development combination, the photographer can control how details are recorded in the highlight, midtone, and shadow areas of an image.

The Curves tool provides the ability to change image contrast by moving the plot points for specific tones, thereby changing the shape of the characteristic curve for the image. The eyedropper serves the function of densitometer, and can be used to measure the tonal values of individual pixels. As the eyedropper is moved across an image, pixel code values are displayed and plotted on the Curves Dialog box. Repositioning the plot points for specific tone changes the pixel code values those points represent. This in turn changes the color of those pixels, and the shape of the characteristic curve.

The characteristic curve is a reflection of image contrast, and changes in direct proportion to a change in the position of plot points. If a plot point is moved down vertically, the pixels that plot point represents will get darker. If it is moved up, the pixels will get lighter. This has a direct influence upon how a viewer perceives details in an image. The human eye has a limited ability to distinguish variations in tone, especially when those variations in tone are very close on the histogram.

Let us use a simple analogy to make this a bit more understandable. Fig. 11.42 shows three kids playing on a seesaw. Using curves, the contrast of one point on the histogram can be increased (to go up on the seesaw), while the other values decrease (to go down on the see saw). The crucial component in the use of curves is to identify the appropriate grayscale values. For example, in the illustration, there are two "ridge" values: Tommy Ridge and Johnny Ridge. There is also a value on the histogram for the "furrow" or background values: Judy Furrow. There is sufficient space (contrast) between the point where Tommy appears on the histogram and where Judy appears on the histogram, which means that it is easy to distinguish between the two shades of gray. On the other hand, the distance between Johnny Ridge and Judy Furrow is very limited, which means the ability to distinguish between variation in tone is extremely limited. The moral of the story is that when selecting the grayscale values for the points on the curve, it is extremely important to pick the lightest ridge value (Johnny Ridge) and not the darkest value (Tommy Ridge). In other words, we do not want Tommy playing on the seesaw. We only want Johnny Ridge and Judy Furrow on the seesaw so that we can increase the contrast between those two points on the histogram.

Following paragraphs list these steps to select the lightest (faintest) ridge and the furrows (background) and adjust contrast between those points. For these steps to work properly, the image must be in grayscale.

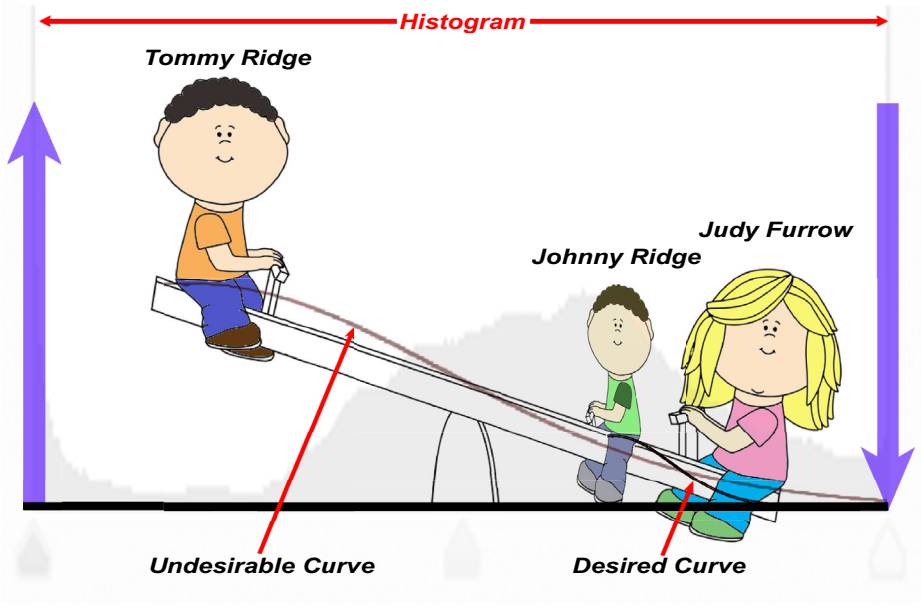


FIGURE 11.42
The Curves function provides the ability to increase the contrast between two grayscale values that are located very close together on the histogram.

RULE OF THUMB 11.23

For best results when using Curves, select the value for the lightest (faintest) ridge and the value for furrows (background) and adjust contrast between those points.

1. Open an image that is low in contrast or that contains an area that is especially dark in comparison to the rest of the image.
2. On the Menu Bar, select Image, Adjustments, and then Curves…, and the Curves dialog box will be displayed as shown in Fig. 11.43. (Please note that the histogram is opposite of what normally appears in Levels. The highlight values appear on the left on the *x*-axis, and at the bottom on the *y*-axis. The shadow values appear on the on the right on the *x*-axis, and at the top on the *y*-axis.)
3. Move the cursor over the image, and the cursor will change into an eyedropper (for sampling).
4. While pressing and holding the Ctrl key, click and hold the left mouse button, and drag the cursor over the lightest (least visible) ridge. A point will appear on the diagonal line in the dialog box, and the point will move up or down on the diagonal line as the cursor moves over the ridge detail in the image.
5. After locating the lowest point of the ridge along the diagonal line (the point closest to the lower left corner), release the left mouse button first, and then release the Ctrl key. The black box will remain at the sample point.
6. To sample for the furrow (background), press and hold the Ctrl key, click and hold the left mouse button, and drag the cursor over the furrow adjacent to the location where the lightest (least visible) ridge sample was taken. A point will appear on the diagonal line in the dialog box, and the point will move up or down on the diagonal line as the cursor moves over the ridge detail in the image.
   Note: The sample for the furrow (background) should appear on the diagonal line about ¼ to ½″ down from (and left of) the ridge sample as shown in Fig. 11.44.
   (Alternatively, the second point can be placed on the diagonal line manually—without actually taking a second sample—by clicking on a point that is about ¼″ (or so) down from the first point on the diagonal line.)

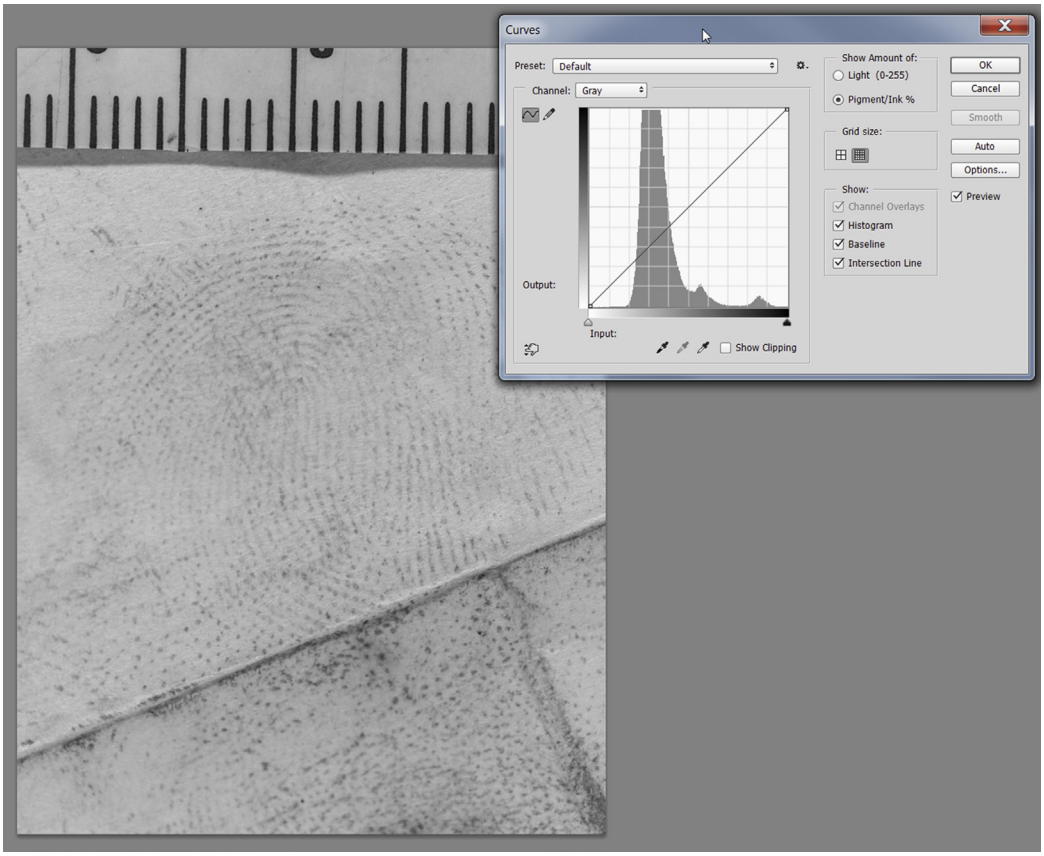


FIGURE 11.43
To help facilitate the selection of grayscale values when using Curves, the histogram is provided in the background to help ensure that the appropriate highlight values are selected.

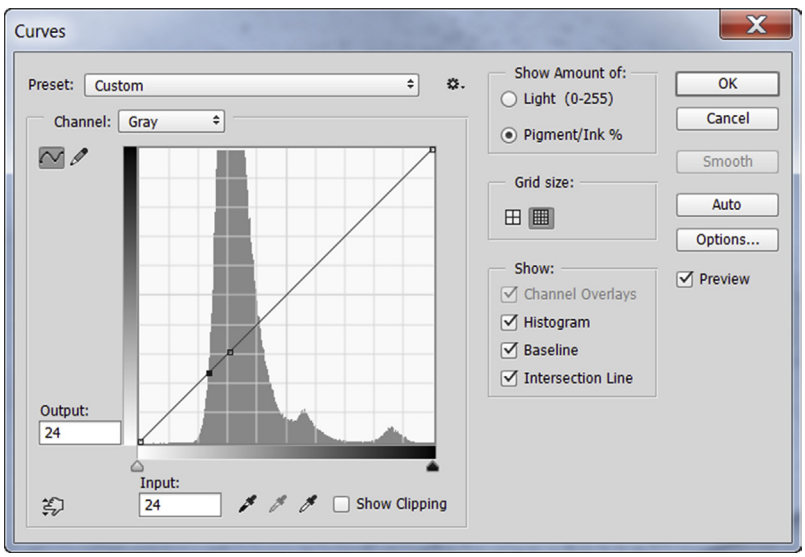


FIGURE 11.44
Two points must be identified on curves baseline. The first point selected is the value for the lightest ridge value for which there is very little contrast between the ridge and the adjacent furrow. The second point represents the value for the adjacent furrow or the background in the image.

7. With the cursor positioned over the second point (the furrow/background sample), click and hold the left mouse button, and drag the point at a 90 degree, perpendicular line from the base line. As the bottom point is moved, the left side of a bell curve will appear in the Curves dialog box, linking the two samples as shown in Fig. 11.45, and the contrast in the image will increase. Ensure that the curve does *not* become a flat line at the top or bottom of the curve (run along the top edge or the bottom edge in the image window) as this is also a destructive process and clips pixel values. Fig. 11.46 shows the image before and after the use of curves.
   Note: For a more accurate contrast adjustment, it may be necessary to isolate a specific area on the image using an area of interest tool and adjust the contrast in that area first, and then bring up the contrast for the rest of the image. The proper procedure for selecting an area of interest is described in the next section.

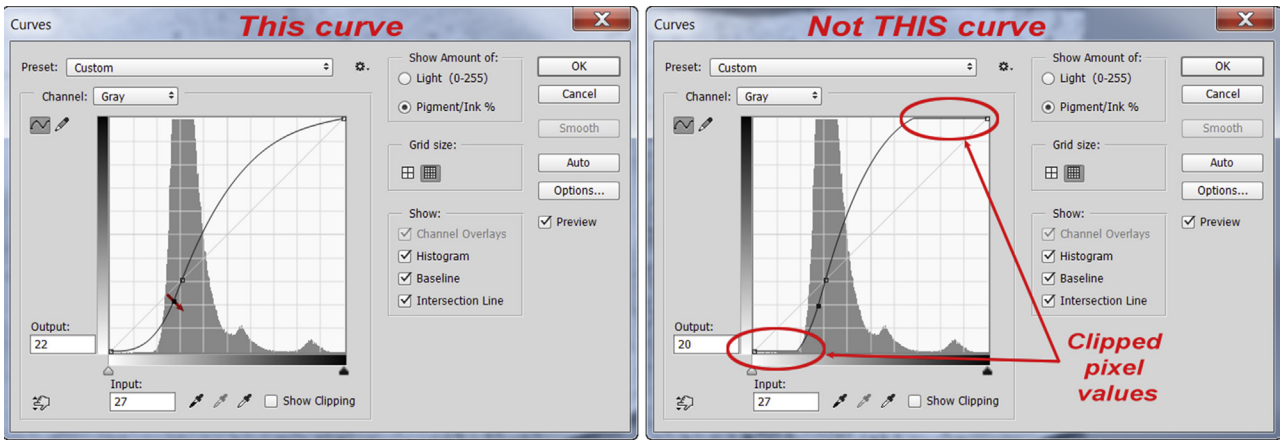


FIGURE 11.45
When the top or the bottom point is moved (the bottom point is moved down in a perpendicular line off the baseline, or if the top point is moved, it is moved up in a perpendicular line off the baseline) a bell curve representing the new contrast value is displayed. Do *not* flatline the curve at the top or the bottom of the curves window as "pixels will be harmed in the completion of this action."

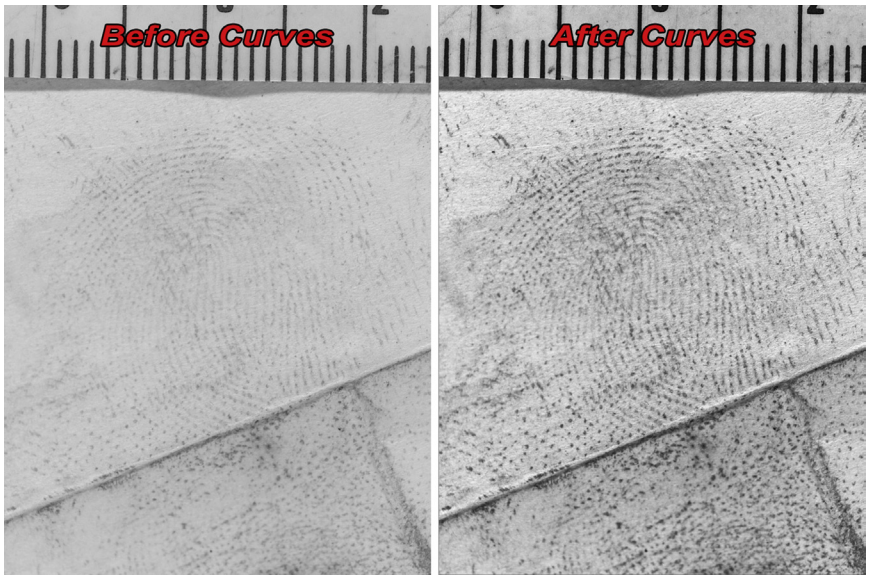


FIGURE 11.46
When the Curves function is used properly, the contrast in the image is increased gradually to provide an image that is much easier to view and analyze.

ADJUSTING TONAL RANGE AND CONTRAST: BURN AND DODGE

In a 2003 case, *State of Florida v. Victor Reyes*, Barbara Heyer (the defense attorney for Victor Reyes) challenged the use of the Burn and Dodge tools because there was no history of "what was done" with these tools. Over the years, numerous people have heard rumors that the use of burn and dodge was rejected in this case, and the enhanced images were not admissible. This is a total, complete, and utterly false rumor. *The use of burn and dodge was not only accepted in the Victor Reyes case, but the use of these tools have been accepted in numerous cases around the country, in Canada, and in Europe.*

RULE OF THUMB 11.24

It is perfectly acceptable to use Burn and Dodge as part of the enhancement process.

Today, the automated History Log in Adobe Photoshop solves the primary concern in the Reyes case because at the time, Adobe Photoshop version 7.0 did not have an automated History Log, which has been available since Adobe Photoshop CS. The other concerns about these tools raised in the Reyes case had to do with brush size. For instance, if used improperly, a small enough brush size could be used in conjunction with the Burn tool to give the "appearance" of altering the image "burning in (adding) ridge detail," and not simply adjusting contrast. Similarly, a small enough brush size could be used in conjunction with the Dodge tool to give the "appearance" of altering the image by "dodging out (erasing) existing ridge detail." This problem has also been resolved because the brush size is recorded as part of the Photoshop History Log.

In response to these concerns, the forensic science community has adopted some general guidelines for the use of these tools to ensure that the use of these tools is not questioned:

When using Brush tools, such as Burn and Dodge, you must use the following guidelines:

1. Always choose a soft (feathered) round brush. As shown in Fig. 11.47, choose a soft round brush by clicking on the brush with the dark center that gradually lightens out to the edge of the circle.
2. Specify the size of the brush by either (a) sliding the size slider button or (b) typing the desired number of pixels for the brush size in the Size text box as shown in Fig. 11.47. After adjusting the brush size, move the cursor onto the image. The cursor should appear as a large circle. Count the number of ridges to ensure that there is a minimum of 8–10 ridges visible inside the circle. A larger brush size can be used, but it should not be any smaller than eight ridges in diameter. The relationship between brush size (number of pixels) and ridge counts will vary depending on the calibrated resolution of the digital image.

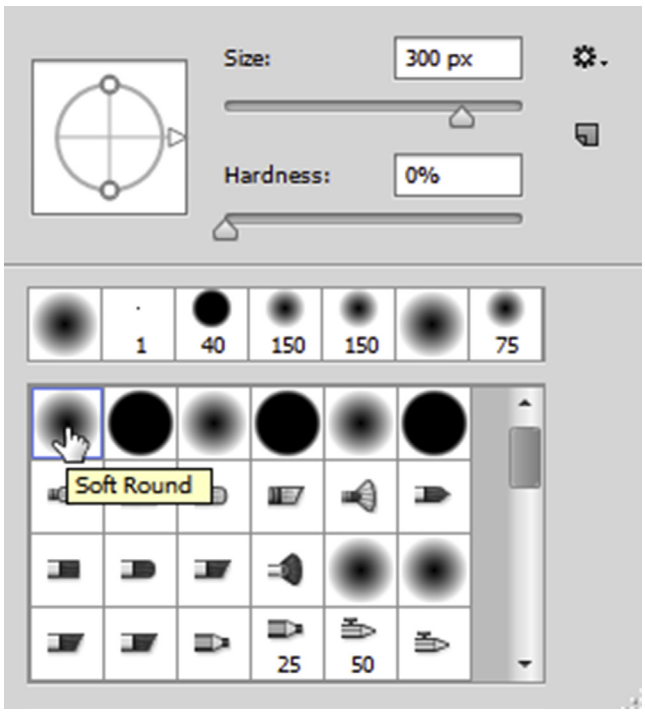


FIGURE 11.47
To use Burn and Dodge, a soft round brush that is a minimum of 8 to 10 ridges must be specified in the tool options settings.

Caution: In addition to using the Brush settings window to adjust Brush size, you can use the left and right square bracket keys ([) and (]) to increase or decrease, respectively, the size of the brush. However, you should not use these shortcuts to adjust brush sizes because changes made using these shortcuts are not recorded in the History Log!

3. When using the Burn tool, choose Shadows for the Range; when using the Dodge tool, choose Highlights. (The Range list box appears to the right of the Brush settings on the Brush options toolbar, which is located directly below the menu bar.) Depending upon whether or not other enhancement processes have been performed on the image, it may be necessary to reduce Exposure. Typically, the Exposure should be set to a range between 25% (if other enhancement processes have been performed on the image) and 50% if no other enhancements have been performed on the image. It is acceptable to go lower than 25%, but going over 50% is more likely to make the burn or dodge functions stand out (be more noticeable) in the image. The goal is to increase the contrast without making the individual enhancements noticeable.
4. For best results when using Burn and Dodge in a "click-and-drag" method, drag the brush *across* the ridge flow, not *with* the ridge flow. When using this method with the brush tool, the brush continuously samples the pixel values as the brush moves over the pixels and adjusts tonal range using previous sample values as well as current sample values. This may leave the appearance of a trail across the image.
   Alternatively, for *optimum* results, position the cursor at a single location, and then click and release the mouse button one or more times to achieve the desired contrast. Using this technique, the increase in contrast for the specific area will be based on the values of that area.

SELECTING AN AREA OF INTEREST: BURN AND DODGE

Another argument made in the *State of Florida v. Victor Reyes* case was that "[h]ow do you know where you used [the] Burn and Dodge [tools]." While the cursor location is not documented each time the mouse button is clicked when using Burn and Dodge, there is a method for recording the location where the Dodge and Burn tools were used in the History Log if you believe it is a concern that you cannot answer in court.

To record the specific location where the Burn and Dodge tools were used, isolate the area to be enhanced using either the Rectangular or Elliptical Marquee tool. The reason for using either the Rectangular or Elliptical Marquee tool is that the coordinates for all four corners of the selected area are recorded automatically in the History Log. In addition, the isolated area is marked with "marching ants" (ie, the outline of the area is marked with a *dashed line* and the dashes flash in a circular motion, giving the appearance of moving, hence the name "marching ants"). There is also another unique characteristic of the "marching ants," and that is, the "marching ants" mark the Las Vegas area of the digital image, and "what happens in Vegas, stays in Vegas baby!" In other words, the use of Burn and Dodge is restricted to the area inside the "marching ants."

Note: The purpose of this discussion is to inform you of one specific technique. It is in no way intended to infer, directly or indirectly, that you cannot or should not use Burn and Dodge without first isolating the area with the Marquee tools. The discussion regarding the use of the Marquee tools is provided *only* as an option for consideration. And it is only for consideration in those jurisdictions where the District Attorney or the State's Attorney has concerns about the digital imaging process. To the best of my knowledge, this has not been a concern anywhere in the United States, Canada, or Europe since at least 2009.

SELECTING AN AREA OF INTEREST FOR ADDITIONAL PROCESSING

Adobe Photoshop provides a number of tools for selecting areas within an image that require special attention (or that requires additional enhancements). These tools are shown in Fig. 11.48.



FIGURE 11.48
Adobe Photoshop provides a number of selection tools to isolate individual areas for special attention and processing during the imaging process.

Additionally, the function Color Range (from the Select menu, choose Color Range) may be used to select a range of color values based on a sampled color value. (While this process is worthy of mention, it is not used frequently in most forensic science applications.) There are, however, advanced digital image-processing techniques that use this application, but those techniques are best learned in a classroom setting under supervised instruction. Therefore, no additional discussion/instruction will be provided for this function in this chapter.

Selecting an area of interest can be extremely advantageous during image enhancement. However, there is one function in Adobe Photoshop called feathering (also known as "blending") that typically must be performed in conjunction with selecting an area of interest. The term "feather" comes from early film-based photography. After the negatives had been developed and were ready to be printed, the individual exposing the paper to light through the negative would use a feather to interrupt the exposure of the paper to lighten an area or darken another area. The feather would often be used in a back-and-forth, side-to-side motion to prevent an outline of the feather (or other tool, such as a piece of paper and a paddle) in the picture.

RULE OF THUMB 11.25

There is one function in Adobe Photoshop that typically must be performed in conjunction with selecting an area of interest: feathering (also known as "blending").

In Fig. 11.49, the image on the left shows an area of an image that was selected and processed without feathering compared to the same selection of the same image being feather and then processed using the exact same technique, settings, and parameters. (In this case, only Levels was used since the grayscale values in the histogram were restricted to a very small area within midtones, and the contrast could be adjusted with no clipping.) The distinct edge where the processing occurred not only makes an unsightly appearance in the image, but also makes it *apparent* that the image was modified. One of the primary objectives of image processing is to ensure that the image appears balanced across the entire image. The processing of individual areas should not be readily identifiable. These areas should blend into the rest of the image.

Fig. 11.50 illustrates what occurs when an area with a distinct contrast edge is selected and not feathered and the same exact area is feathered and processed using the exact same technique, settings, and parameters. When an area is feathered, the blending occurs based upon the number of pixels set for feathering both inside and outside the marching ants as a gradient. The gradient also affects how the area inside the gradient is enhanced as well. When an area with an edge is feathered, the gradient blending leaves the edge because the gradient decreases on either size of the marching ants, so the darkest part of the gradient occurs where the edge appears in the image. When the area is not feathered, the edge values can be reduced to match the background leaving a more balanced image. (By leaving a dark gradient at the edge of the contrast area, the pixel values in the area of the edge can also appear to be out of focus and blurry.)

Therefore, feathering should not be used with selection tools based on edges with a contrast of 10 or more grayscale levels. These tools include: the Polygonal Lasso, the Magnetic Lasso, Quick Select, and the Magic Wand. Selections made using all other selection tools must be feathered with the exception of areas that are selected and then inverted. A blurry grayscale halo effect will appear instead of a gradient blending of the area selected.

There are two options for feathering a selected area:

1. When any of the area of interest tools listed above are selected, the tool options for that function are displayed on the tool options bar, which is located directly beneath the menu bar. In the Feather text box, type the desired number of pixels to be feathered. Each time the tool is used, the selected area will automatically be feathered using the preset feather radius.
2. If the feather radius was not preset, or it is necessary to increase the feather radius *after* an area has been selected: from the Select menu, select Modify, and then select Feather …; or press the shift key and tap the F6 key (Shift + F6). The Feather Selection dialog box will appear. Enter the desired number of pixels for Feather Radius. (The process for determining the feather radius is discussed below.) The "Apply effect at canvas bounds" should not be enabled (there should not be a checkmark in the checkbox). And then click OK. The location of the marching ants will be adjusted (smoothed) and the area is ready for the next processing technique.

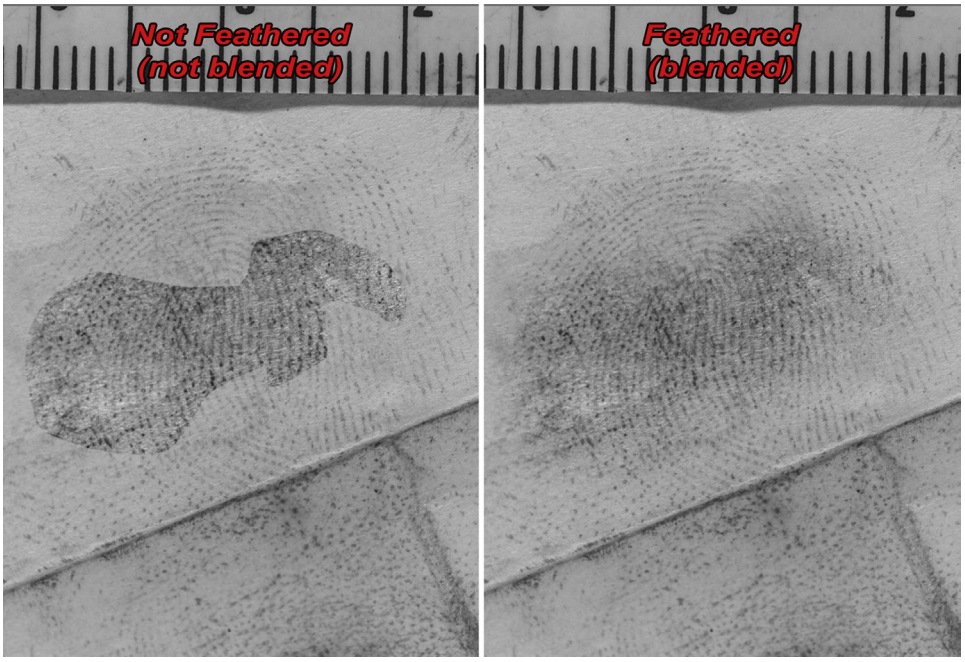


FIGURE 11.49
If the selection is not feathered (blended) into the rest of the image, a very distinctive edge is created in the processed image, which can be very distracting.

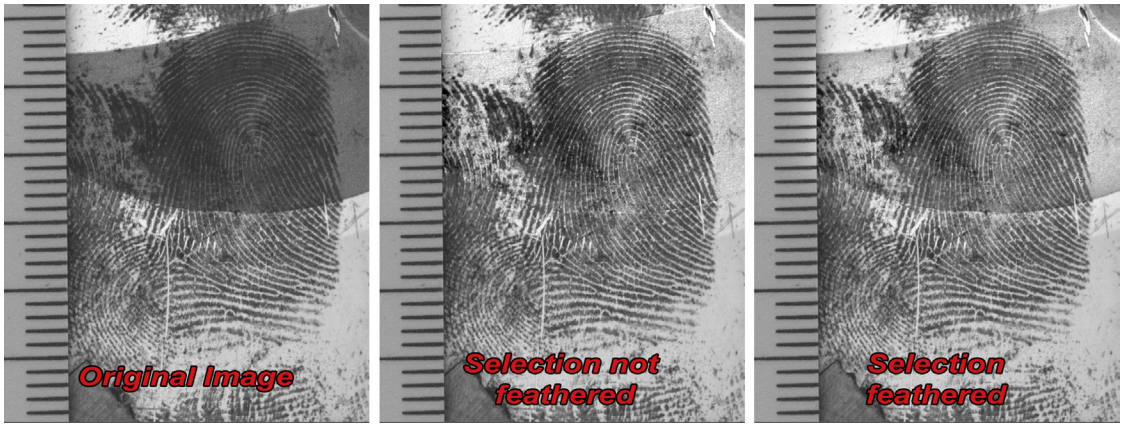


FIGURE 11.50
Areas that are defined by a contrast that creates an edge separating a portion of the image from the remainder of the image, the selected area should not be feathered because it does not diminish the edges.

DETERMINING THE FEATHER RADIUS

The concept of feathering a selected area is based upon the desire to make an area that has been processed independently to blend in with the rest of the image. There are no firm, fixed guidelines for determining the feather radius, and the method for determining the feather radius is different for processing different types of impression evidence (latent prints, tool marks, footwear, and tire marks) as well as questioned documents, trace evidence, and firearms (which is different for things such as serial number restoration, gunshot residue, casing and cartridge characteristics, and so forth).

RULE OF THUMB 11.26

There are no firm, fixed guidelines for determining the feather radius, and the method for determining the feather radius is different for processing different types of impression evidence (latent prints, tool marks, footwear, and tire marks) as well as questioned documents, trace evidence, and firearms (which is different for things such as serial number restoration, gunshot residue, casing and cartridge characteristics, and so forth).

But regardless of the forensic discipline involved, there are two elements to be considered when determining the feather radius for forensic digital imaging: (1) the calibrated resolution of the image (PPI) and (2) the size of the area selected.

Generally speaking, any digital image with a calibrated resolution that is greater than 1000 PPI uses a simple formula for determining the pixel radius, while images with a calibrated resolution that is less than 1000 PPI use the size of the selected area for determining the pixel radius.

For images with a resolution less than 1000 PPI, the guideline is to:

- Use a minimum pixel radius of 50 pixel when selecting a small area within an image.
- Use a minimum pixel radius of 75 pixel when selecting a medium area within an image.
- Use a minimum pixel radius of 100 pixel when selecting a large area within an image.

Again, these are just recommendations, and it may be necessary to increase or decrease the pixel radius if the level of blending within the image is less or more than desired.

For images with a resolution greater than 1000 PPI, the recommended guideline for determining pixel radius is more established, and there are different formulas that may be used to provide the same result. Below are two different formulas to arrive at exactly the same number. Some users prefer Option 2 although it requires a couple of additional steps, but they prefer it because the math seems a bit simpler. The bottom line is choose whatever formula is easiest for you.

Option 1: Using the calibrated resolution for the image (PPI; to review the resolution, from the Image Menu, select Image Size, and then mentally note the resolution (PPI) value), mentally round up the resolution to the nearest 100 (eg, 1323 PPI would be rounded up to 1400 PPI), then divide that number by 20 for the pixel radius (ie, 1400/20 = 70).

Option 2: Using the calibrated resolution for the image (PPI; to review the resolution, from the Image Menu, select Image Size, and then mentally note the resolution (PPI) value); mentally round up the resolution to the nearest 100 (eg, 1323 PPI would be rounded up to 1400 PPI); divide that number by 100 (ie, 1400/100 = 14); and then multiply that number times 5 (ie, 14 × 5 = 70). Again, the result is the same, but may be easier for some users. (*Note*: There is no specific reason or magic used in selecting the number 5 as the multiplier when determining the number of pixels for pixel radius, but it does allow us to use two different formulas to determine the number of pixels for pixel radius.)

Regardless of which formula you use for determining the feather radius for images with a resolution greater than 1000 PPI, it may be necessary to reduce the number of pixels when selecting very small areas in which the gradient from one side of the selected area overlaps the gradient for the opposite side of the selected area. In this case an error message will be displayed which reads: "*Warning: No pixels are more than 50% selected. The selection edges will not be visible.*" In this case, there are two options: (1) select a larger area so there is no overlap of the gradients; or (2) decrease the number of pixels specified for pixel radius. And sometimes you just want to increase the pixel radius because "bigger is better" and you are selecting a bigger area.

The bottom line is that there is no rule that must be followed when determining the pixel radius. The goal is to use a "reasonable" pixel radius so the area being processed does not stand from the rest of the image.

Eliminating Noise or Hotspots, and/or Sharpening the Image

As discussed earlier, the majority of digital cameras have a CFA overlaying the imaging sensor in the digital camera. The camera (or the computer in the case of an RAW image) calculates pixel color values using a demosaicing algorithm that creates the color values using the brightness values (and filter information) from the neighboring photo sensors as shown in chapter "Digital Imaging Technologies," Fig. 10.16. The conversion process can cause an image to appear blurry, especially in 12- or 14-bit images that have been reduced to only 8-bits per color channel. This process can also cause sensor noise to become more noticeable in processed RAW images.

The *Dust and Scratches* filter can also be used to blur minor background noise, such as dots seen when digitally capturing impression evidence on printed materials or the weave pattern of clothing or bedding materials when evaluating digital images of bloodstain or gunshot residue. For example, with Dust and Scratches, noise elimination is done by looking for pixels that exceed a difference of *x* number levels of brightness (typically a difference from 30 to 40 levels of brightness) from its neighbors and assuming that pixel value is an anomaly (aka frequency spike), and then changing the value of that pixel to the average of its two immediate neighbors.

- Radius: Controls how many pixels are considered when comparing the contrast of each pixel to the neighboring pixel values. Typically, the Radius is based upon 1–2 pixel for every 1000 PPI in the calibrated resolution; the lower the resolution, the lower the ratio of pixels (ie, 1 instead of 2 pixel). For high-resolution images (usually images exceeding 3000 PPI) the ratio can be higher (ie, 2 pixel per 1000 PPI).
- Threshold: Controls the range of correction made to the pixel block. A lower threshold decreases the correction, making the image appear more blurred, whereas a higher threshold increases the range of correction, making the image appear sharper. The range for Threshold is 0–50. Settings above 50 produce results that are not readily visible even when displayed on a high-resolution monitor. Typically, the higher the Radius setting, the higher the threshold. For example, with a Radius of 1, the Threshold would be set between 1 and 10; with a Radius of 2, the Threshold would be set between 10 and 20; with a Radius of 3, the Threshold would be set between 20 and 30; with a Radius of 4, the Threshold would be set between 30 and 40; and with a Radius of 5, the Threshold would be set between 40 and 50. (Personally, I cannot recall ever using a radius of 4 or 5 because the blur becomes too much of a distraction/distortion.)

While the Unsharp Mask and the Dust and Scratches filters are not used exclusively for the purpose of correcting demosaicing and imaging sensor issues in RAW files, they are most commonly used for that purpose, as discussed in the following paragraphs.

Demosaicing is a process that must be frequently addressed when processing camera RAW images. This is typically done using the Unsharp Mask command. (You can also use the Smart Sharpen command if you so desire.) This process can also help "refocus" an image if it appears slightly out of focus.

In the *Unsharp Mask* dialog box, you can adjust the following settings:

- Amount: Controls how much you want to increase the contrast for the correction. The typical range for this value is between 50 and 100. Values over 100 tend to create too much contrast within the image.
- Radius: Like Dust and Scratches, the Radius controls how many pixels are considered when comparing the contrast of each pixel to the neighboring pixel values. The Radius for Unsharp Mask uses the same guidelines as Dust and Scratches, which are based upon 1–2 pixel for every 1000 PPI in the calibrated resolution; the lower the resolution, the lower the ratio of pixels (ie, 1 instead of 2 pixel). For high-resolution images (usually images exceeding 3000 PPI) the ratio can be higher (ie, 2 pixel per 1000 PPI).
- Threshold: Controls the range of correction made to the pixel block. Using Unsharp Mask, the range for the threshold is the same as Dust and Scratches, however, the results are the opposite: a lower threshold increases the correction, making the image appear sharper, whereas a higher threshold decreases the range of correction, making the image appear more blurry. (*Note*: The Threshold setting in Unsharp Mask allows the entry or use of the slider bar to enter a decimal value, such as 3.7 pixel. For forensic science applications, this setting should be constrained to the use of whole number values only.) The range for Threshold in Unsharp Mask is the same as is in Dust and Scratches, which is between 0 and 50. Settings above 50 produce results that are not readily visible even when displayed on a high-resolution monitor. Typically, the higher the Radius setting, the higher the threshold. For example, with a Radius of 1, the Threshold would be set between 1 and 10; with a Radius of 2, the Threshold would be set between 10 and 20; with a Radius of 3, the Threshold would be set between 20 and 30; with a Radius of 4, the Threshold would be set between 30 and 40; and with a Radius of 5, the Threshold would be set between 40 and 50.

Before JPG images are written to the storage media in the camera, they are processed inside the camera. In addition to demosaicing, JPG files are also filtered (for noise reduction) and sharpened before they are saved in the camera. As a result, sharpen and noise reduction filters are not required for processing JPG images.

Flatbed scanners, on the other hand, do not use a CFA. Therefore, scanned images are not subjected to the demosaicing process. Most flatbed scanners also have a noise reduction filter integrated into the scanning software. This means the use of Dust and Scratches and Unsharp Mask filters are rarely used on digital images captured using a flatbed scanner.

In addition, some high-end (expensive) printers (such as Fuji and Noritsu) also have additional noise reduction and auto sharpening filters built into the printer driver for producing images that appear to be more clear. Most dye-sublimation printers also have noise reduction and auto sharpening filters built into the printer drivers because of the high level of resampling required to reduce the resolution of high-resolution digital images. Unfortunately, these features are *not* included in the print drivers for most commercially available off-the-shelf (COTS) ink-jet printers. Therefore, the use of Dust and Scratches and Unsharp Mask is highly recommended and encouraged for maximum print quality.

RULE OF THUMB 11.27

Most commercially available ink-jet printers do not have noise reduction and auto sharpening filters built into the printer driver for producing images that appear to be clearer. Therefore, the use of Dust and Scratches and Unsharp Mask is highly recommended and encouraged for maximum print quality.

Rotating the Image

In some instances, it is necessary to rotate a digital image for the preparation of notes or reports, or to create illustrations, such as the comparison of a latent impression and a known impression. As a result, the need for a digital image with the proper vertical or horizontal orientation outweighs the artifacts created when rotating an image.

In this case, it is critical that the rotation of the image be postponed until after all digital image processing has been completed with the image. It is also recommended that the processed image be saved prior to rotating the image so that in the event additional image processing is required to adjust tonal range, etc., additional processing can be performed using the original pixel values and not the artifact values resulting from the rotation process.

Digital images should also be rotated once and ONLY once! Far too often people rotate their image only to realize that it was rotated too much or it was not rotated enough. Once they make that realization, they rotate the image again, either rotating more in the same clockwise direction or rotating it backwards in a counterclockwise direction. As a result of this additional rotation, the artifacts produced from the first rotation are subjected to additional artifacts, and that is never a good thing!

RULE OF THUMB 11.28

Digital images should also be rotated once and *only* once! Images subject to multiple rotations are subjected to additional artifacts based upon the previous rotation artifacts, and that is never a good thing!

Follow the procedure described below when rotating an image is absolutely necessary and essential for the analysis and/or comparison of the image:

1. From the toolbar, select the Ruler tool (as shown earlier in Fig. 11.14 under Calibrating Digital Images, Option 1).
2. Position the Ruler tool cursor at the location that would be the top position when the image is rotated, and then click and hold the left mouse button and drag the cursor though the image creating a line that is to be the vertical axis of the rotated image.
3. When the cursor is located at what is to be the bottom of the image, release the left mouse button. With the Axis line present in the image window, the Straighten Layer button (on the tool options bar, which is located directly beneath the menu bar) is not active.
4. Move the cursor over the Straighten Layer button and click the left mouse. The image will be rotated in accordance with the axis created in step 3.
5. Depending upon the angle of the axis in relationship to the orientation of the original image, the image will either be rotated so that the image is displayed with the appropriate vertical orientation, or horizontally.
   Note: If the axis line has an orientation that is between 45 and 90 degree, the image will be rotated to a vertical orientation. If the axis line has an orientation less than 45 degree, the image will be rotated to a horizontal orientation. The reason for the vertical/horizontal rotation is so that the image is rotated with the fewest degrees to minimize the artifacts caused by rotation. As shown earlier in this chapter in Fig. 11.7, the rotation of 45 degree has a lesser impact than the rotation of 75 degree. If the image is now horizontal, but must be rotated 90 degree for a vertical orientation, the image can be rotated the second time with no further degradation because rotating images at 90 degree does *not* create artifacts within a digital image.

Saving the Processed Image

After successfully enhancing a digital image, you must save the image in a noncompressed file format, such as TIF, PNG, or PSD. SWGIT is now considering the adoption of JPG 2000 (JP2) compression for saving processed digital images. But as stated earlier, the JPG specification does not support the use of layers, so I do not recommend the use of ANY JPG algorithm to store processed images.

Also, we stated earlier in this chapter that the parent–child relationship between the original and copy of an image must be maintained so that the images can be identified properly in accordance with Federal Rules of Evidence 901. As a minimum, save the original as well as the final enhanced image as two separate images.

If the enhanced digital image will be used for any other purpose, such as a latent print or palm print that must be entered in AFIS, follow these steps:

Caution: The following steps will degrade image quality. Therefore, be careful how and where you store the adjusted image file resulting from these procedures. Be careful not to overwrite not only the original image file, but also the enhanced copy of that file.

1. Copy (duplicate) the enhanced image file and preserve the integrity of the enhanced image together with the original image file.
2. Open the copy (duplicate) of the enhanced image file in Adobe Photoshop.
3. Confirm that the image has been changed to Grayscale (from the Image menu, choose Mode, and then choose Grayscale).
4. Rotate the image, if necessary.
   Note: It is recommended that you rotate digital images before submitting an electronic image file to AFIS. As discussed earlier, rotating an image can cause aliasing within the image as well as other artifacts caused by manipulating color values. The effects of rotating an image are less noticeable (and damaging) on a higher-resolution image than they are on a lower-resolution image.
5. From the Image menu, choose Image Size. The Image Size dialog box will be displayed on the screen.
6. Make sure the Resample Image option is enabled. (When the Resample Image option is enabled, a checkmark will be displayed in the Resample Image check box, and the Resolution field will not be linked to the Width and Height fields.)
7. Change the Resolution (PPI) to match the AFIS specifications. (The Resolutions for AFIS are typically 500 and 1000 PPI.)
8. From the toolbar, choose the Crop tool.
9. Crop the image in accordance with the AFIS requirements. (The crop sizes for AFIS clips are about 1.25″ by 1.25″ or 1.50″ by 1.50″.)
10. Save the new image in a noncompressed file format, such as TIF, PNG, or BMP, in accordance with AFIS guidelines.
    Note: You are not required to retain the "AFIS-ready" image. After you have submitted the image to AFIS, you can discard the post-enhancement processed ("AFIS-ready") image to eliminate the possibility of confusion in the future. More specifically, since both the resolution and pixel (grayscale) values have been altered by both the rotation and resampling processes, you do not want to save the post-processed image instead of the final enhanced image.

Creating Overlays

There is one additional process that must be included in this book because it is used extensively by footwear examiners and questioned document examiners. This process is also applicable in a number of other forensic science disciplines. This process is not, however, recommended for use with impression evidence, such as fingerprints, palm prints, and bite marks due to the elastic nature of skin because it stretches easily, causing distortion that could be misinterpreted easily.

Step-by-step, detailed instructions are provided for this process because it is not only relevant, but because the lack of knowledge about this process has had a significant impact in at least three different cases. In the case of North Carolina versus Billy Ray Bridges, the photographer did not know how to create an overlay properly and the attempt at doing so created confusion about the images resulting in the digital images not being admissible in court.

In the State of Connecticut versus Alfred Swinton, Alfred Swinton was on trial for the rape and murder of a female victim. During the trail, the odontologist testified about the matching dentition of the defendant with the bite marks found on the body of the victim. During the trial, the trial court determined that the images (digital images used to create overlays showing the dental impressions of the suspect on top of the bite marks on the victim) were admissible. Upon appeal to the Court of Appeals in Connecticut, the defense argued that the computer generated exhibits were introduced by an expert with "no more than an elementary familiarity" of the program (Adobe Photoshop). In fact, the odontologist had no idea how to create the overlays and relied upon the expertise of an individual in the photo lab at the time to create the overlays. And the odontologist could not answer even basic questions, including whether or not the process of creating overlays was a customary practice within the field of odontology. To make matters even worse, Major Timothy Palmbach, a supervisor for the Division of Scientific Services in the State of Connecticut Department of Public Safety stated in his testimony that "… Adobe Photoshop was capable of actually altering photographs."[2]

[2]Guthrie, K., Mitchell, B., 2007. The Swinton Six: The Impact of State v. Swinton on the Authentication of Digital Images National Clearinghouse for Science, Technology and the Law at Stetson University College of Law: Gulfport, FL http://www.ncstl.org.

Upon the appeal, the Court of Appeals decided that the images were in fact, improperly admitted, and that decision was appealed to the Supreme Court in the State of Connecticut. On appeal, the State argued "that the exhibits were merely photographic or illustrative evidence and not scientific evidence. Therefore, admissibility of the overlays did not require the testimony of a witness who could explain the inner working of the equipment that produced it to provide an adequate foundation."[3]

In its decision, the Connecticut State Supreme Court concluded that the computer-enhanced photographs had been properly admitted into evidence, but concluded that the overlays created using Adobe Photoshop were improperly admitted because the odontologist had relied upon the overlays to reach a conclusion and in fact had "no more than an elementary familiarity" with Adobe Photoshop.

The Supreme Court also upheld the verdict of guilty because there was more than enough other evidence presented during trial to prove beyond a reasonable doubt that the defendant was guilty.

The second case where overlays were used to obtain a guilty verdict had far more devastating results. In the State of Arizona versus Ray Krone, Krone was wrongfully convicted twice of killing a Phoenix woman based on expert testimony that purportedly matched his teeth with bite marks found on the victim.

The forensic odontologist used dental casts, Styrofoam impressions, and CAT Scans of dental casts of the Krone's teeth and created overlays of the impressions on top of autopsy pictures of the actual wounds and testified that the impressions matched Krone's teeth. During the trial, however, the odontologist explained away all of the anomalies (inconsistencies) that appeared in the overlays.

(When I first started researching this case, I was curious what "Styrofoam impressions" were because I had never heard of them before. After reading more about the case, I found out that the suspect was required by the police to make bite impressions in Styrofoam cups—yep, you read that right, Stryofoam coffee cups—for comparison with the bite marks found on the victim. But I digress.)

Krone was found guilty and convicted in 1992, and he was sentenced to death. After two and a half years on death row, his conviction was overturned on procedural grounds and a new trial was ordered. Krone was convicted a second time in 1994 using the same overlays that had been submitted during the first trial. After hearing the testimony of the odontologist again during the second trial, the judge said he was not confident that Krone was, in fact, the killer, and he spared Krone the death penalty but sentenced him to life in prison.

In 2002, new DNA tests were conducted, and the tests results proved that Krone was not the killer. The DNA from the victim was linked to a man already in prison for another crime that involved the same MO (modus operandi). In 2002, Krone was released from prison after serving more than 10 years in prison, two years and eight months of which were spent on death row, wrongfully convicted of a crime that he did not commit based upon a conclusion from improperly prepared overlays. (Even though they were improperly prepared, the overlays still contained inconsistencies that should not have been explained away. One of the arguments made in the case involved the imperfections of digital imaging.)

Now that everyone is all freaked out about creating overlays, let us talk about how to create an overlay *properly*. As stated earlier, this process works extremely well with evidentiary items such as footwear impressions and questioned documents because there is typically limited distortion caused by "elasticity" of the item leaving the impression. The steps involved are as follows:

1. Calibrate the images to ensure that they are scaled for accurate, life-size (1:1) output.
2. Complete any required digital image processing (enhancement), and ensure that the images are converted to grayscale.
3. Save the processed images, and make a copy of the saved images for creating the overlay.
4. Open the images to be used for the overlay in Adobe Photoshop.
5. Review the image resolution for both images (Image>Image Size).
6. Select a common denominator for the resolution (PPI) for both images. The highest resolution of the two images is typically recommended for the common denominator; hopefully that is the resolution of the digital image for the questioned impression and not the digital image of the standard, or the known item. In fact, I personally use the resolution of the questioned item for the common denominator because I do not want to add any additional distortion caused by resampling that image.
7. Select the image in which the image resolution needs to be adjusted so that the two calibrated images will have the same resolution.

[3]Ibid.

8. In the Image Size dialog box as shown in Fig. 11.51, enable Resample (a checkmark should appear in the check-box immediately to the left of the Resample option). To increase the resolution of this image to match the higher resolution of the two images, select the resample option "Bicubic Smoother" (enlargement).
9. Enter the resolution of the other image so that the two calibrated images will have the same resolution.
10. Click OK to close the Image Size dialog box and complete the resizing of the image.
    Note: For ease of visualization in this medium, the figure shown for the remainder of this discussion will use a questioned signature and a known signature so that when zoomed in the images will appear more clearly. (The zoomed view of a large object, such as a footwear impression would not be as visible.)
11. To view the detail in the questioned signature when overlaying the known signature, change the color of the first signature to Red.
    a. From the Image menu, select Adjustments, and then select Hue/Saturation.
    b. As shown in the Hue/Saturation window in Fig. 11.52, enable the Colorize option on the right side of the dialog box. A checkmark should appear in the check box to the left of the Colorize option.
    c. By default, the slider will appear on the left side of the Hue option, which is red.
    d. Move the slider under Saturation to the far right, which will display 100.
    e. Move the slider under Lightness to the right, to 55.
    f. Click OK in the upper right corner to lock in the new color values.
12. Repeat step 11 with the standard (known) signature, changing the standard to Green.
    a. From the Image menu, select Adjustments, and then select Hue/Saturation.
    b. Enable the Colorize option on the right side of the dialog box. A checkmark should appear in the check box to the left of the Colorize option.
    c. Move the slider under Hue to the right, to approximately 120.
    d. Move the slider under Saturation to the far right, which will display 100.
    e. Move the slider under Lightness to the right, to 55.
    f. Click OK in the upper right corner to lock in the new color values.
13. Place the signatures side by side: from the Windows menu, select Arrange and then select 2-up Vertical as shown in Fig. 11.53.

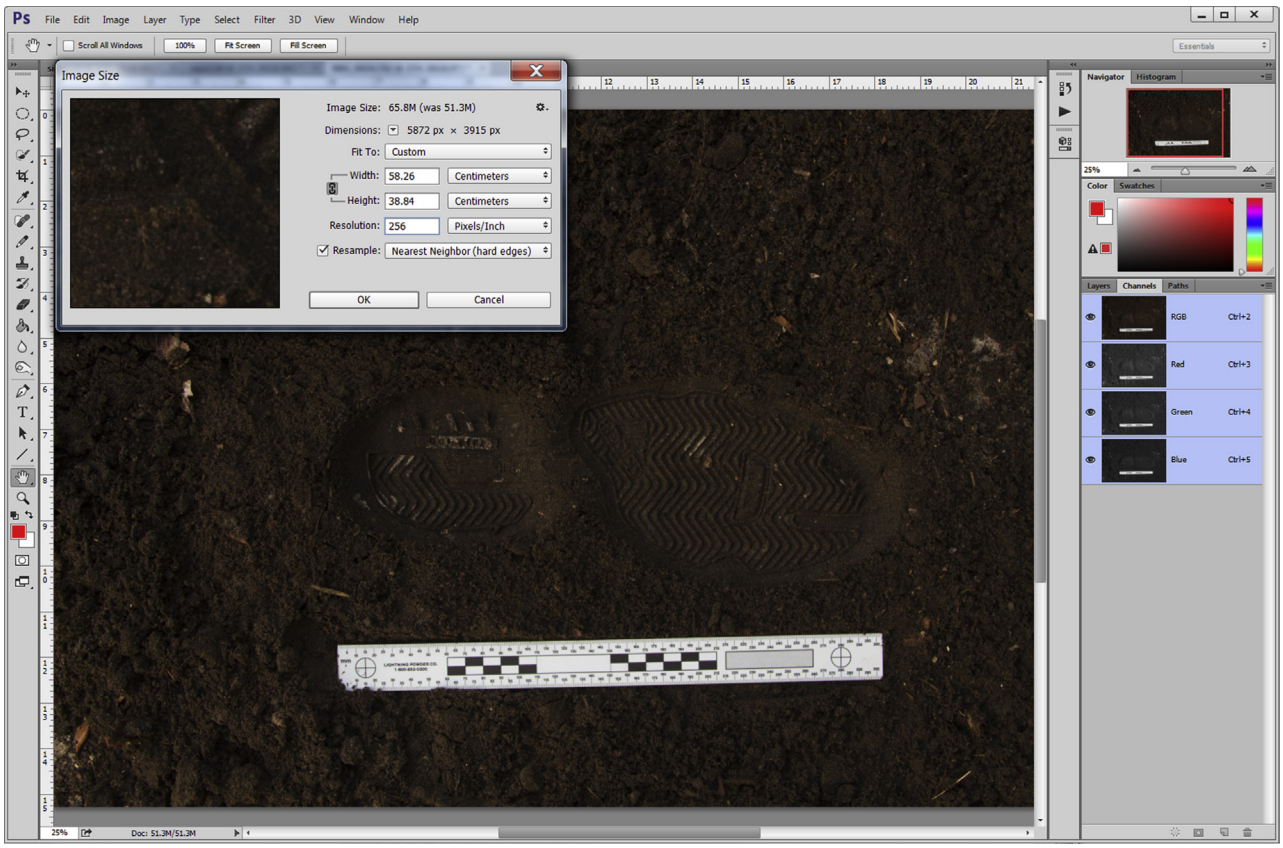


FIGURE 11.51
When resampling an image so that the resolution of one image matches the resolution of the other, resampling must be enabled and the appropriate resampling technique must be selected.

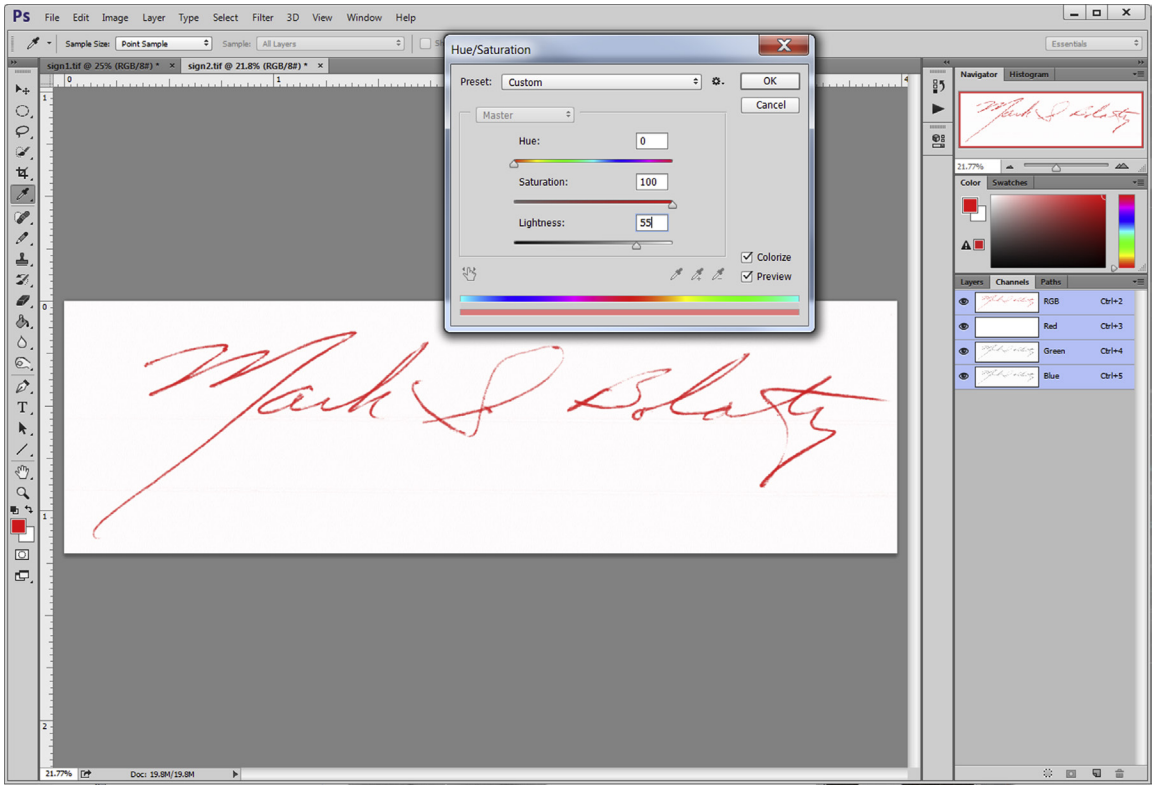


FIGURE 11.52
When creating overlays, changing the color of the items using Hue and Saturation helps to view the similarities as well as quickly identify the differences between the images when they are overlayed.



FIGURE 11.53
To facilitate the moving of one image on top of the other, it is much easier if the two images are displayed side by side.

14. Select the Move tool from the toolbar, or type the letter V to enable the move tool.
15. Move the cursor into the image window containing the questioned signature and click the left mouse button.
16. Place the tip of the arrow in the cursor on a characteristics that will be used for positioning the questioned signature on top of the standard in the other image window as shown in top image Fig. 11.54, and click and hold the left mouse button.
17. While continuing to hold down the left mouse button down, drag the cursor into the other image window, and the cursor will change shape it moves from one window into the other.
18. Position the tip of the arrow in the cursor on top of the corresponding position identified in step 16 above as shown in the bottom of Fig. 11.54, and release the left mouse button.
19. Now that both signatures appear in one window, side by side display can be dismissed. From the Window menu, select Arrange, and then select Consolidate All to Tabs.
20. Click on the Layers tab in the Layers/Channels/Paths panel on the right side of the Photoshop window.

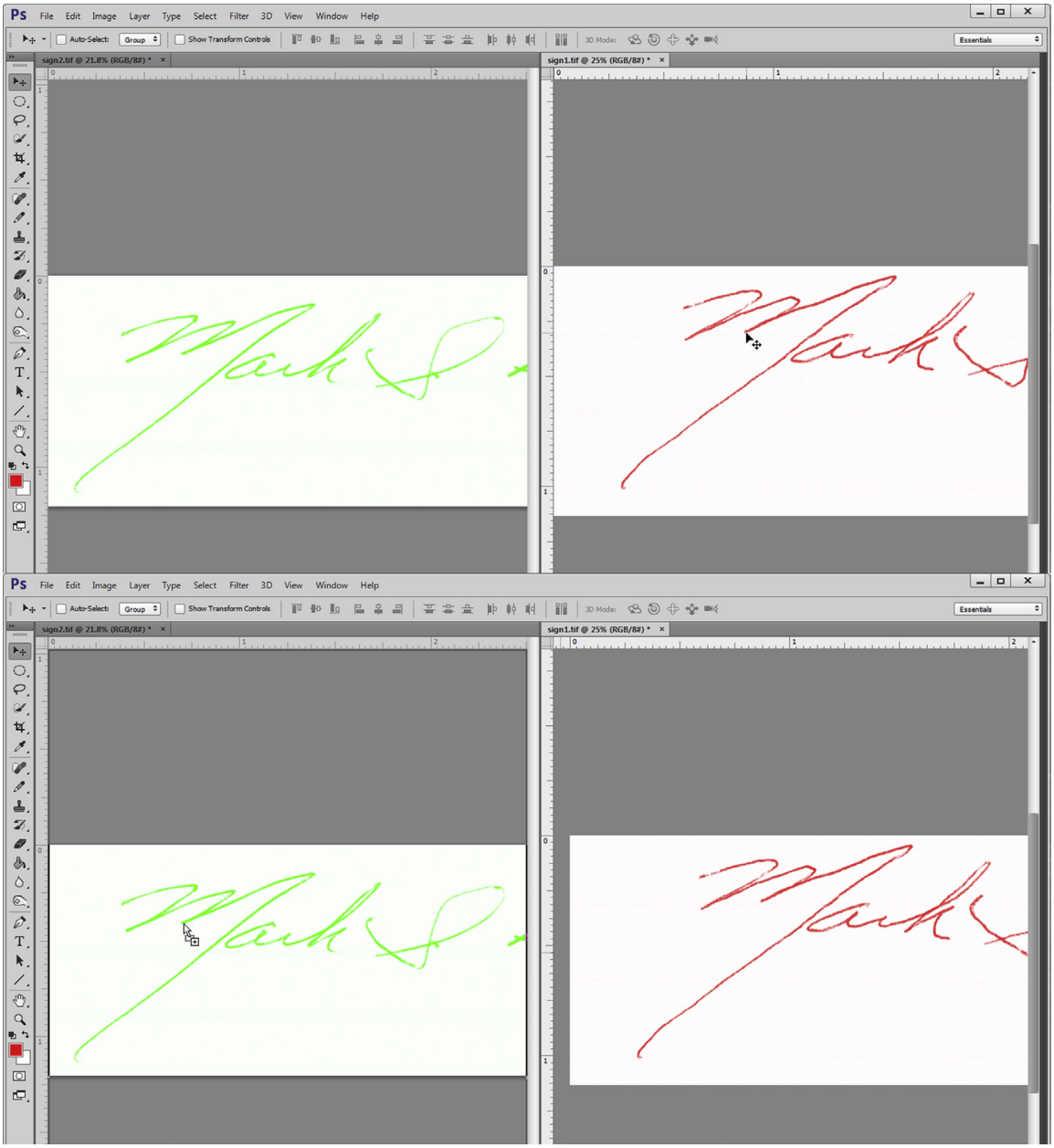


FIGURE 11.54
Aligning images when moving one image on top of the other is very easy. Simply position the tip of the cursor arrowhead at a point in the top image for which there is a corresponding, easily identifiable characteristic in the bottom image. Then click and hold the left mouse button and move the cursor into the other image window and position the tip of the cursor arrowhead at the corresponding point and then release the mouse button.



FIGURE 11.55
Once the images are aligned properly, the areas where the image detail is consistent appears as a dark gray (black) color value, while the areas that are inconsistent in the two images will appear in their assigned color.

21. Beneath the menu bar for the Layer tab is a blending option selection box. The default option that appears in this box is Normal. Click the down arrow and choose the option "Darken" as shown in Fig. 11.55. The white background of the top signature will now be transparent, and both signatures will be visible.
22. Using the move tool (and aided by the left/right/up/down arrow keys on your keyboard), you can align the signatures so that one signature is on top of the other.
23. *Optional*: It may be necessary to use the Free Transform function (Ctrl + T) to adjust the orientation of the top layer to match the orientation of the underlying layer.
24. When the alignment and orientation of the images are satisfactory, save the overlay as a TIF file.
    Once the images are aligned, the intensity of the red and green color values of the matching portions of the images will appear as dark shade of gray (black). The areas where the images do not match will be very noticeable because the visualization of the red and green color values will be very apparent.

SUMMARY

Increasingly, people who capture [recover] and process digital evidence seldom have adequate training. And, unlike other physical evidence, there is no agreed-upon standard protocol for capturing, storing, retrieving, processing, analyzing, and documenting the analysis and comparison of digital evidence.

Rarely are questions asked in court about the validity or reliability of the software or about the knowledge, training, or expertise of the person using the software, which many law enforcement agencies think is a good thing because many of the individuals who process digital evidence do not understand the software nor do they know how to use the software to its fullest potential.[4]

One thing can be said about the enhancement of digital images: "It isn't boring!" In fact, there is nothing boring about it at all. Each digital image presents a unique challenge.

[4]Kassner, M., Digital Forensics resembles the Wild West when it comes to regulation, Tech Republic, 14 August, 2015 (see also: Bowers, Mike. "Digital 'forensic science' has blossomed by regulations and firm protocols are lacking," 17 August 2015. FORENSICS in FOCUS @ CSIDDDS | News and Trends).

Digital images come from a number of sources, such as digital cameras, film scanners, flatbed scanners, and video cameras. In addition, the digital images can also come in an array of formats, such as RAW, TIF, JPG, and BMP. The digital image files can also come in a wide range of resolutions, even if they come from the same source.

In some instances, basic image enhancement techniques can be used effectively and efficiently to enhance the digital image. In other cases, more advanced techniques are required. But regardless of the type of processing being done, law enforcement agencies should look for ways to mitigate potential challenges for admissibility by

- Following established/approved SOPs
- Using commonly accepted image-processing techniques
- Using appropriate equipment/file formats
- Collecting standardized data
- Developing standardized reporting
- Extending peer review
- Developing a culture of quality improvement

You should also remember that no matter how many digital image–editing tools you have at your disposal, what you do during the image enhancement process as well as how successful that process is depends on how the image is originally captured. (And there is always the issue that not everyone's image can be improved even with the best image enhancement tools!)

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CHAPTER 12

Legal Issues Related to Photographs and Digital Images

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Key Terms
Authentic
Fair and Accurate Representation of the Scene
Lossless Compression
Lossy Compression
LZW
Manipulation
Material
Osacs
Prejudicial
Processing
Raw
Reasonable Expectation of Privacy
Repeatable
Relevant
SWGIT, SWGTREAD, SWGFAST

Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the elements for a photograph to be considered "a fair and accurate representation of the scene";
2. Explain what is meant by requiring the photograph to be "authentic";

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3. Explain why all photographs taken at a crime/accident scene may not be admissible in court: to be admissible they have to be "relevant" and "material";
4. Explain the requirement that a photograph has to be more probative than prejudicial.

CRITERIA OF PHOTOGRAPHS AND DIGITAL IMAGES AS EVIDENCE

A review of the literature and the case law provides the crime scene photographer with the distinction between when photographs and digital images are admissible in court as evidence and when it would clearly be reversible error to admit them. Between these extremes, it is well known that the trial judge has the ultimate discretion to either admit images as evidence in a court proceeding or to refuse to admit them as evidence.

To be admissible as evidence, an image must be **Relevant** to an issue being contested. The image must also tend to either prove or disprove a disputed or **Material** issue. An image must also be "**Authentic**." The image must finally be established to be "a fair and accurate representation of its subject matter."

Conversely, it would be improper to admit an image as evidence if it were not relevant to issues before the court or if it did not assist the trier of fact in understanding an issue essential to the outcome of the trial. If the image is an unfair representation of the subject of the image, it should also not be admitted as evidence. How can an image be an unfair representation of its subject matter? If it grossly distorts pertinent aspects of the photograph, if it falsely represents the subject matter, if the image is deceptive, and if the image tends to mislead the viewer, then the image should not be admitted in evidence during the trial.

At times these distinctions are clear. At times, judges must use their discretion, and their ruling generally will not be overruled unless they clearly abused their discretion. A third possibility exists. The image may be admissible, but the jury may then decide what weight they choose to give the image. The jury may consider the image as an extremely important aspect of a case, or the jury may totally disregard the image, even though it may technically be admissible. "It is well to remember, however, that there are good photographs and poor photographs just as there are good witnesses and bad witnesses" (Scott, 1969, p. 29). Once an image is admitted in evidence, the jury may assign that image the weight they believe is appropriate.

A Fair and Accurate Representation of the Scene

All photographs offered in court as evidence are required to have the proper foundation laid before they can be accepted. Someone will have to testify that the photograph is a **Fair and Accurate Representation of the Scene** as it was at the time the photograph was taken. This person does not necessarily have to be the photographer who took the original photograph, but it does have to be someone who was present around the time the photograph was taken. Several aspects have to be considered for a photograph to be considered "fair and accurate."

Exposure

Normally, a photograph has to be properly exposed for it to survive challenges in court. A grossly overexposed or underexposed photograph may be held to be inadmissible simply because it does not accurately represent the scene as it was. There are two well-known exceptions to this requirement that a photograph be "properly" exposed:

1. At times, a witness will testify as to what he or she saw in dimly lit conditions. If a photographer is attempting to photograph the scene from the viewpoint of this witness and to duplicate the lighting conditions that originally existed, a well-lit photograph is not the "proper" exposure. In this situation, an underexposed photograph may be the only "proper" exposure.
2. When examination quality photographs are being taken, with the ultimate view of having the photographs serve as a standard for a comparison with a known item of evidence, the photographer often "brackets" the exposures. This means that additional photographs are taken that intentionally underexpose and/or overexpose the original image. When this series of photographs is turned over to a crime laboratory examiner to attempt to compare the photographs to an item of real evidence, the examiner may decide an otherwise "improperly" exposed image may actually show the identifying feature he or she is interested in better than the "well-exposed" version of the photograph.

For instance, examine the three photographs of a bite mark to a hand shown in Fig. 12.1. One was taken with the camera's proper exposure, and the other was intentionally underexposed, a –1 bracket. A third exposure, a –2 bracket, is also included. The three images were taken so that the forensic odontologist could make up their own mind as to which image best shows the outlines of the teeth necessary for a comparison with the known teeth of a suspect. Camera exposure systems try to provide the photographer with proper exposures. In this case, the subject matter most prevalent in the viewfinder was Caucasian skin. It is not the Caucasian skin, however, that is the most important aspect

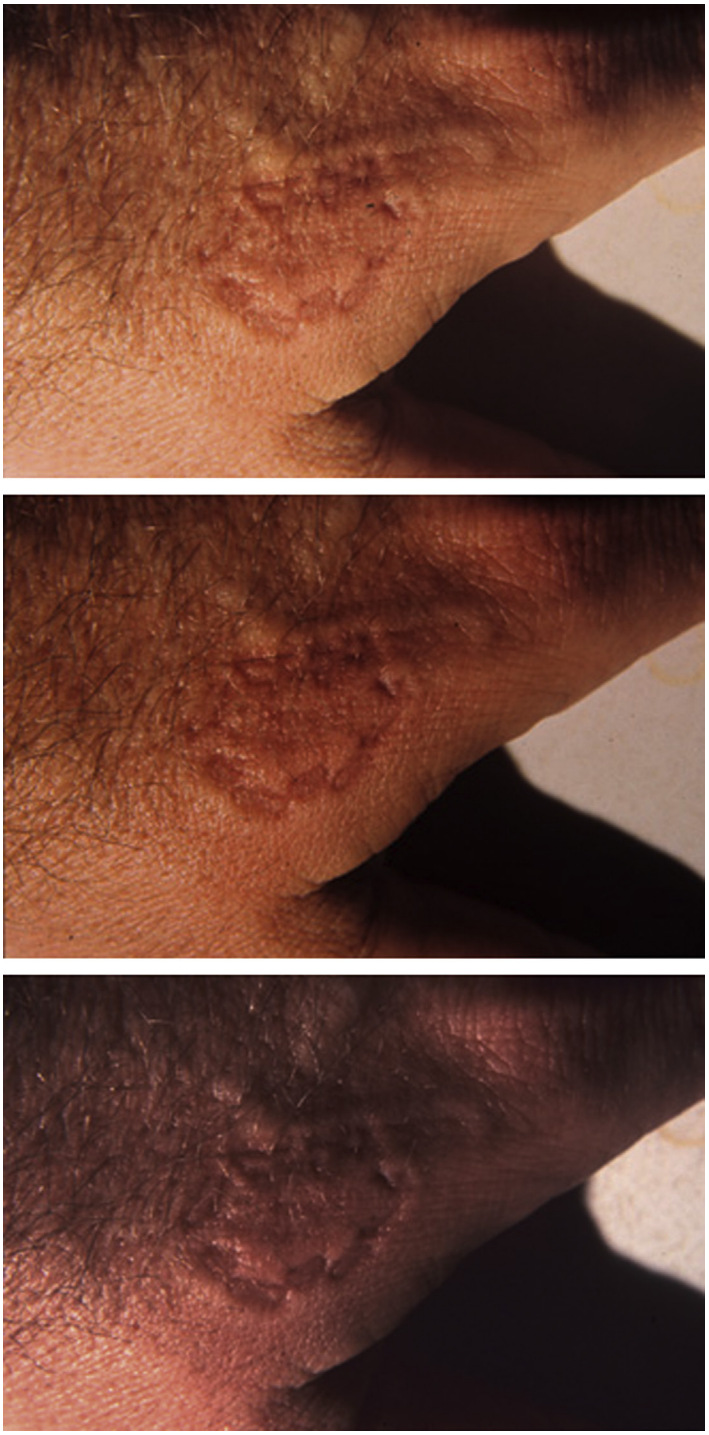


FIGURE 12.1
Bracketed bite marks: normal, –1, and –2.

of this image; it is the bite mark in the skin. Underexposing the skin actually shows the definition of the edges of the bite mark better. The examiner may, therefore, go to court with one of the underexposed photographs offered as evidence, and it will be admissible even though one aspect of the photograph is underexposed.

Color Accuracy

It is normally critical for a photograph being offered in court as evidence to have accurate colors. Imagine a case of a fatal hit-and-run accident, where a paint transfer from a green suspect vehicle to the blue victim vehicle is part of the probable cause by which the officers decide to arrest a suspect in a car with fresh damage and a similar-colored paint as is found at the accident scene. Ensuring the colors of the paint in the photograph are accurate can become a pivotal aspect of the trial.

Several methods ensure colors are accurately captured:

1. If the image is captured by midday sunlight, the digital sensor will record the proper colors. Early morning and late afternoon sunlight will transmit a colored tint to the photograph that does not accurately portray the colors present at the scene. This light has a tendency to be tinted orange or red.
2. If midday sunlight is not available, the colors can be accurately captured if an electronic flash is used as the light source. The light emitted by an electronic flash is color balanced so that it will accurately render colors. It is also necessary to use electronic flash whenever indoor photographs are taken because tungsten and fluorescent lighting will also tint daylight color films. These tints will normally be yellow and green, respectively.
3. As previously mentioned, color correction filters can also be used to correct the tints that may be caused by various lighting situations.
4. With digital cameras, a proper selection of the white balance will also help ensure the colors of a scene are accurately captured by the camera.

Probably the best way to ensure that the **printed** images show an accurate range of colors is to include a color scale in critical photographs. If the digital image depicts the color scale accurately in the print being offered in court, it can be assumed the other colors in the image are also colored properly. Of course, at times a witness may have seen an event under poor lighting conditions or in lighting conditions that would produce tints onto objects. In these situations, the photographer would be attempting to replicate the poor lighting conditions.

In Fig. 12.2, a white vehicle has been tinted to appear yellow because of the ambient lighting. If the issue in court is why the police stopped and detained a suspect driving a white vehicle when the witness reported seeing the suspect

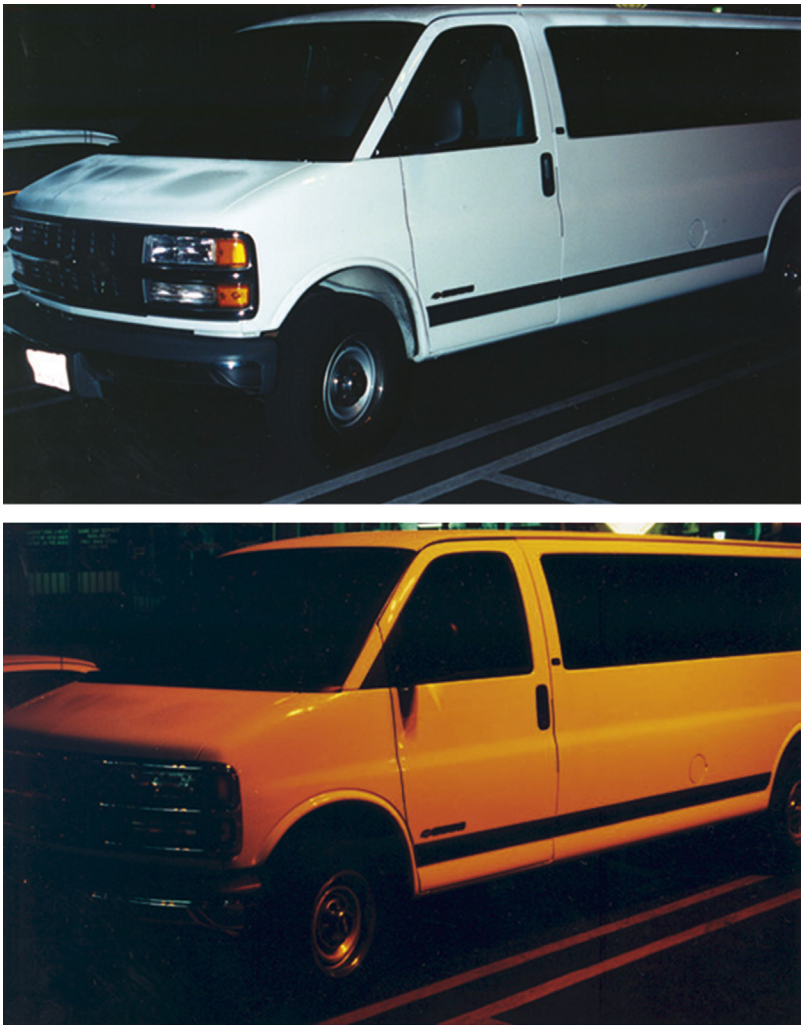


FIGURE 12.2
A white vehicle tinted yellow because of ambient lighting.

driving away from the crime scene in a yellow vehicle, these two images will explain the matter clearly. Of course, it will be necessary for the photographer to duplicate the yellow tint in one of the photographs. That is not the accurate color of the vehicle, but it is the accurate color of what the witness saw.

Distance Relationships

Photographs should accurately portray the correct distance relationships present at the original scene to be admissible in court as evidence. When the portrayal of an accurate distance is an issue in the court, normally two methods ensure that the distances depicted in the image are accurate:

1. It is normally critical to have taken the original photograph with a normal focal length lens, which will not distort the relative distances in the foreground and the background. Either wide-angle lenses or telephoto lenses will tend to create a perspective distortion that falsely represents reality. As mentioned previously, wide-angle lenses will elongate the relative distance between foreground and background, and telephoto lenses will compress this same area. The result is that the perceived distances between features of the scene will be inaccurate with any focal length other than the normal lens. If the lens being used on the camera at the time is a zoom lens, it is critical that the normal focal length setting be used when the image is captured.
2. Even when a normal focal length lens is used, it is then essential that the distance in question be viewed with the photographer positioned so that he or she is equal distances from the two items in question. This has been expressed as the photographer being perpendicular to the imaginary line drawn between the two items in question; or, the photographer forming an isosceles triangle with the two items of interest, with the two items of interest equal distances from the photographer. If the photographer uses a normal lens but then orients himself or herself so the evidence and the photographer form a straight line, which is called a linear perspective, the two items of evidence will appear closer together than they really are.

Accurate distance relationships require both the proper lens and the proper perspective view of the evidence.

Focus/Depth of Field

It is crucial that all important aspects of the photograph are in focus. If an important aspect of the photograph is out of focus, the photograph may be declared inadmissible as evidence.

Therefore, it is essential that the range of what appears to be in focus, the depth of field, covers all the areas in the photograph that are important. In many cases that means everything in the picture.[1]

A brief return to chapter "Composition and Cardinal Rules" on composition may be required here. If you know an area will be out of focus, you should try to recompose the scene so that those areas that will be out of focus will no longer appear in the composition. The photographer at a crime/accident scene must constantly be adjusting camera controls to maximize the depth of field. When it is known that the depth of field will be inadequate to ensure the entire expanse will be in focus, the photographer should consider recomposing the scene to include only the areas that will be in focus.

Creative photographers frequently intentionally throw unimportant aspects of their composition out of focus, usually to force the viewer to look at the main subject who is in focus. Crime scene photographers usually do not have this option. Intentional blurring of parts of the scene, although perfectly acceptable for creative photographers, should not be a photographic technique used by crime scene photographers. The crime scene photographer should first try to maximize depth of field so that everything in the composition is in focus. After that, if background or foreground areas are known to fall outside the depth of field range, recomposing the images is called for.

An obvious exception to the usual prohibition of crime scene photographers to intentionally blur aspects of photographs is if a fingerprint is on a window, and the photographer cannot place a sheet of paper on the opposite side of

[1] "A photograph that is not clear and sharp may be likened to a witness who does not speak distinctly and is hard to understand. Both the blurred photographs and the inarticulate witness may contribute something of value despite their imperfections…a photograph ordinarily is admissible for what it is worth even though it is somewhat out of focus and therefore of little value. However, it is not an abuse of discretion for the trial court to exclude out of focus photographs even though it would not be an error to admit them." (Miss. Butler v. State, 179 So.2d 184, 253 Miss. 760 (1965); W.Va. Elswick v. Charleston Transit Co., 36 S.E.2d 419, 128 W. Va. 241 (1945) (court did not err in refusing to admit photograph that was obscure and not sufficiently clear to aid jury.) Indiana: Taylor v. State, 295 N.E.2d 600, 260 Ind. 264 (1973), cert denied 94 S. Ct. 377, 414 U. S. 1012, 38 L. Ed.2d 250 (fact that pictures are far from good examples of photography goes merely to weight of evidence rather than to admissibility). S. C.–Brooks v. Brooks, 339 S.E. 2d 531, 288 S. C. S. C. 71 (App. 1986) (whether photographs were of sufficient quality to be admissible was a matter up to the discretion of the trial judge) (Tex. Jimenez v. State, 787 S. W. 2d 516, 524 (App. 1990) (appellate court suggested that in the event of retrial the trial court should reconsider its ruling admitting blurred photograph in evidence). See Scott (1969, p. 395).

the window to eliminate background views behind the fingerprint. The crime scene photographer can then photograph the fingerprint with a wide aperture of the lens to intentionally blur the background elements so they do not compete with the fingerprint ridge details. Because of the previous discussion on the widest aperture of the lens tending to be aberration-limited, the aperture 2 stops in from the widest aperture is optimal in this situation.

Size

At times, it is critical that a photograph be compared with another item of evidence; for instance, if a shoe print pattern is located and photographed at a crime scene, it would ultimately need to be compared with a suspect's shoe when that is recovered. For this comparison to be made, it is necessary for the original image of the shoe print from the crime scene to be enlarged to a life-size print. This can be done only if the original photographs included a scale, and if that scale is placed on the same plane as the shoe print. That means if the evidence is a partial shoe print on a raised surface and the photographer is focusing on the top of the raised surface, the scale needs to be raised to the same level of the top of the raised surface by placing objects under the scale to raise it to the proper height. If the evidence is a shoe print in dirt, and the photographer is focusing on the depth of the shoe impression, for instance, ½″ below the dirt's surface, the scale needs to be lowered to the depth of the shoe print in the dirt. The photographer must dig a trough next to the shoe print and place the scale in the trough at the same distance from the sensor as the evidence.

Fig. 12.3 shows images of two scales, placed at different distances from the film plane. When positioned equidistant from the camera, the scales are the same size; or 1″ looks like 1″ on both scales. However, even when one of the scales is just ¼″ from the other, a size difference already exists. This difference in relative sizes becomes more apparent as the scales are moved ½″ from the focal plane. A scale that is placed on a different plane than the evidence will inaccurately represent the actual size of the evidence. The question is this: can a scale placed at a different distance from the actual plane of the evidence enable an image to be enlarged to the true size of the evidence? It cannot. Therefore, it is critical, when taking images of evidence that will eventually be compared with a known item of evidence, that you ensure that the scale is placed at the same plane, high or low, as the evidence.

One other interesting aspect should be pointed out when scales are not on the same plane as the evidence: look at Fig. 12.3 again carefully, and you should be able to notice that the further scale is just a little bit out of focus. It becomes progressively more apparent as the scales become further apart, but even at ¼″ difference, the further scale is just a little bit "soft." The scale is still readable but not quite as sharp as the scale that was focused on, which is a second reason to place so much emphasis on ensuring the scale is on the same plane as the evidence. Not only will a misplaced scale misrepresent the size of the evidence, the scale will also be slightly out of focus. This may make a photographer seem less than competent at trial. Camera-to-subject distance is one of the factors that affect the depth of field range, and as these distances become closer and closer together, the depth of field range shrinks until virtually no depth of field is present in extreme close-ups other than what is actually focused on. In other words, if you focus on a bloody fingerprint on a knife blade and place the scale on the floor next to the knife, there will be two consequences. The scale will be both slightly out of focus, and it will not enable a life-sized photo of the fingerprint to be made because the scale lies on a different plane than the fingerprint.

Authentic

An authentic photograph consists of a fusion of two concepts that will be discussed in the following sections.

As Found

For the most part, photographs taken at crime/accident scenes should portray the scene as it was originally found before any alterations, which is sometimes referred to as being "as-is," and sometimes this has been referred to as photographing the scene "in situ" or in the situation as it was originally found. Nothing should have been moved or removed before the photographs are taken. Nothing should have been added to the scene before the photographs are taken. As with everything in life, a few well-known exceptions to this mandate exist:

1. Police banner guard, yellow crime scene tape, is frequently added to secure the perimeter of a scene to protect it and to keep unnecessary people out of the scene. However, just before the exterior overall photographs are taken, this banner guard can sometimes be temporarily removed so that artificial elements are not introduced into the scene. When removing this guard is impossible or impractical, the courts have normally "understood" this obvious alteration of the perimeter of the scene.
2. Traffic cones are frequently placed around a scene for the same reasons. Because they are easily accessible to law enforcement agencies, they are frequently used to quickly mark the positions of evidence throughout the scene. Again, they should be removed before the photographs are taken because the original scene did not have them present.

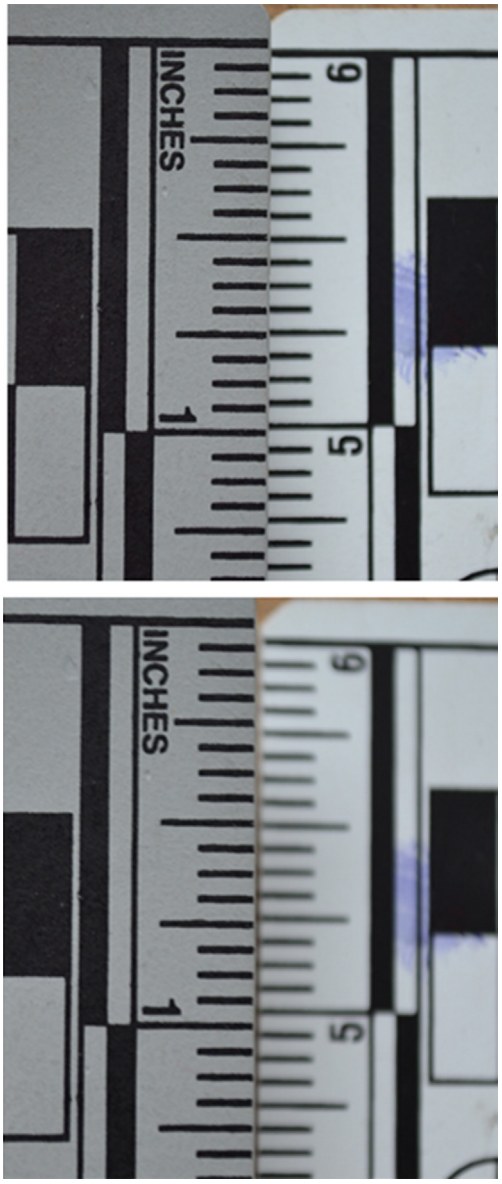


FIGURE 12.3
Scales at different levels.

3. At times, evidence may have been picked up and taken into custody before a photographer has been able to take the photographs of the scene "as-found." One situation that may mandate the early collection of some of the evidence is the presence of a hostile crowd when weapons or drugs are obviously present within the crime scene. Some in the crowd may have vested interests in removing evidence from the crime scene. Because such evidence may be valuable commodities, many may be tempted to "acquire" the evidence for possible resale later; the "souvenir" collector is always interested in gathering a memento of the occasion. For these reasons, and others, it may be prudent to collect some of the evidence before the crime scene photographs can be taken. These types of evidence should not be replaced in the scene just before the photographs are taken. This may falsely give the viewer of the photograph, usually the judge or jury, the impression that the photograph is of the crime scene before any alteration. It is better to train all first responders that if early evidence collection is justified, a surrogate item, like a crime scene numbered or lettered marker, can be placed in the same location of the evidence just picked up. Then, the scene can be photographed with the surrogate evidence in view, and the testimony of the officers removing the evidence "early" can justify their actions and the photograph with surrogates in the crime scene. Everyone understands and accepts the need to occasionally pick up a golf ball and temporarily replace it with a ball marker left in its place. In the crime scene scenario, however, no effort will be made to replace the evidence where the marker has been placed.

In situations in which evidence has been picked up and collected and no marker has been left in its place, the scene will then be photographed without the evidence within the scene, and it will be up to the evidence collecting officer to justify the collection and try to verbally explain to the court the location of the evidence within the scene. No attempt should be made to replace the evidence within the scene in the location the officer believes most likely is the position the evidence had been in.

In one jurisdiction at the scene of a police shooting, a rookie officer located the suspect's gun hidden behind a garage. So pleased with this discovery, the rookie proudly brought the gun to his supervisor standing at the curb in front of the incident. When the supervisor informed the rookie that crime scene investigators were almost at the scene, the rookie disappeared. When crime scene technicians arrived at the scene, they were directed to the rear of the garage, where the suspect's gun was photographed "as found." During the subsequent trial, this entire scenario was brought to light. Police disciplinary proceedings quickly followed the trial of the suspect: not just for the rookie, but for the supervisor as well.

The approach of bad weather can also justify the early collection of evidence. Crime scene photographers do not have to idly stand by as high winds blow away the evidence, heavy rains wash it down the street, or warm weather evaporates the evidence. Early collection is mandated in such circumstances. If evidence has been removed before the photographs have been taken, the scene is photographed "as found" by the photographer, with some of the evidence already missing. It will then be up to the individuals removing the evidence to justify doing so and to have it admitted in court solely on the basis of their testimony, because photographs will not be available showing it in the scene. Perhaps a well-planned photograph with a perspective grid in view might be considered in such situations. If time does not permit photographing all the evidence in place, perhaps one photograph can be composed with many items of evidence in view with the perspective grid.

Recreations

Reenactments or recreations of crime scenes or accident scenes are permissible only as long as no effort is made to suggest those photographs are of the original scene. Recreating scenes has many legitimate purposes; for instance, to allow a jury to determine whether a witness may have been able to actually see an event from a particular vantage point under certain circumstances. Such restaging, however, must always be well documented as such to avoid recreations ever being mistaken for the original event.

More and more, the technology exists to create mini-movies and animations of one side's version of the sequences of a crime scene that are proposed recreations of the original event. These are not misperceived as being original scene reproductions. However, at times, still photographs are created to supplement the recreations. Efforts must be in place to avoid having the jurors misunderstand these images as original "as-is" images.

Relevant and Material

All the photographs taken at a crime/accident scene may not later be admissible in court as evidence. How can this be? How can all the homicide crime scene photographs, for example, not be admissible in court? For photographs—or any type of evidence for that matter—to be admissible in court as evidence, they must also meet another two-pronged test: they have to be both relevant and material.

"Relevant evidence is any evidence that tends to prove or disprove any disputed fact in the case. No evidence can be admitted to prove facts that are not at issue" (Kaci, 1995, p. 51). By the time of the actual trial, there may be many issues that are not being contested or that are being stipulated to. In these situations, it is not necessary to "prove" a nondisputed issue, and it would be a waste of the court's time to permit such evidence being admitted. Many photographs are taken at a major crime scene "just in case" they will later be needed at trial. Many of the images taken at major crime scenes are no longer relevant to the trial that is being presented. For instance, many images of the wounds to the victim will be taken, both at the crime scene and at the autopsy, in case the manner and cause of death are disputed in the subsequent trial. If the defense team offer an insanity plea and do not deny their client caused the death or the death mechanism, then all these photographs may be declared irrelevant to the trial. The only issue will be whether the defendant is sane or insane. The entire crime scene scenario offered by the prosecution may be stipulated to. However, if images suggest rational planning, those may still be admitted as relevant to the issue of sanity.

The Federal Rules of Evidence, Rule 401, defines relevance somewhat differently: "Relevant evidence" means evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence. Perhaps the same meaning with different legalese? The evidence has to have some probative value to the court proceedings.

Material evidence, to the layman, is frustratingly similar to relevant evidence. "Material evidence is evidence that is important to the case; it cannot be too remotely connected to the facts in issue" (Kaci, 1995, p. 51). Material evidence is offered to prove or disprove a fact in issue. If the evidence does not relate to any issues pertaining to the case, it is not material.

At one homicide scene, the victim's back door was kicked in. Much effort was used to photograph the damage to the back door, anticipating it to be proof of a forced entry to the crime scene. Many midranges and close-ups were taken of the back door, both from the inside and outside. Several hours later, a neighbor who was interviewed stated the deceased had previously locked himself out of the residence and had damaged the door trying to regain entry to his own house several days before the homicide. All those photographs of the back door immediately became irrelevant and immaterial to the homicide investigation.

"In practice, relevant evidence is material only if it meets both of these tests:

1. It must be relevant to some fact that is at issue in the case.
2. It must have more than just a remote connection to the fact" (Kaci, 1995, pp. 51–52).

As stated previously, many of the original photographs taken at a particular crime scene "just in case" may or may not be needed later for the trial. Their use will be based on what issues are being disputed during the trial. For example, perhaps 200 photographs were originally taken at a particular crime scene. Later on, it may be that the only issue currently in dispute in the trial is whether the defendant shot the victim at close range during a struggle for the gun or whether the defendant shot the victim from a greater distance. It may not be disputed that the defendant shot the victim. In this situation, photographs used to establish the range of fire, the gunpowder stippling pattern around the entry wound on the victim, are still admissible, but photographs and casts of the trigger impression on the forefinger of the defendant may no longer be relevant to the case.

It was not wrong to have taken the original 200 photographs. However, by the time the case goes to trial, only a dozen or so images may still be relevant and material to the case.

More Probative Than Prejudicial

Evidence that is otherwise relevant and material to the case may not be admissible in court if the evidence is judged to tend to adversely prejudice the jury against the defendant or inflame the jury against the defendant.

Examples of such photographs might be those that show mutilations or wounds on small children who are universally regarded as innocent victims. The judge has the right to exclude such images that may prejudice the jury against the defendant in court more than they tend to prove an issue being contested in that trial. If the judge believes such photographs would tend to upset the jurors to the point that they may lose their objectivity and forget the defendant has not yet been found guilty, the images may be excluded. These same images, however, may later be deemed to be admissible after the defendant has been found guilty, during the sentencing deliberations, to set the penalty, if a range of sentencing options exist that the jury can choose from.

Sometimes, gory or gruesome images also fall into this same category. The judge may reason that, although the images certainly tend to prove that the defendant did what he or she is charged with doing, the images still have an overwhelming tendency to upset the normal sensitivities of the jury members. In these cases, the judge may exclude the images on the basis of their tendency to prejudice the jury against the defendant. Different judges may view the same images differently. Sometimes it is difficult to anticipate how the judge may react to the images offered in the case. In these cases it is often prudent to have a "Plan B" if you draw a judge willing to exclude such images. Many crime scene photographers come prepared for such possibilities. The first image offered to the court as evidence will be a full-color photograph. Just in case the judge objects to the color photograph, a black-and-white version of the color photograph is ready to be offered to the court.

Fig. 12.4 shows a close-range shotgun wound to the neck, both in its original color version and in a black-and-white version. If a judge decides the color image may be too upsetting for the jury, it may be possible for the same judge to accept the black-and-white version. Better the black-and-white version than nothing. Always have a "Plan B."

"The court is cautious about admitting evidence if it would be likely to arouse either hostility or sympathy for either side" (Kaci, 1995, p. 52). This quote suggests two additional ideas. The image cannot overly prejudice the jury in favor of the victim, and the image should not prejudice the juror against the victim. Usually, the latter issue does not occur often. Why would the prosecution offer an image in court as evidence that did not show the victim in a favorable light?



FIGURE 12.4
Color and black-and-white version of the same image.

As the previous image of a rape victim at the end of chapter "Crime Scene Photography" demonstrated, it is possible to do this unknowingly. The tattoos on the victim's hands may not mean much to most people, but it only takes one juror to hang up a jury, and if one juror saw that image and acquired the wrong impression about the victim, the case may be in jeopardy.

Is it not the job of the prosecution to show the victim in a favorable light? Certainly. But if an image goes over the top while doing this, the image may also be held to be inadmissible. Photographs are routinely shown to a variety of people while trying to determine who the victim really is. If the recognition of the victim from a photograph becomes a disputed point in the trial, having a young girl in her white Confirmation or First Communion dress does more than help identify the child. It produces undue sympathy toward the victim. That photograph may be held to be inadmissible.

The judge is the final arbitrator when challenges to the relevance, materiality, or the **Prejudicial** nature of photographs are raised. Prepare the images intended to be presented in court as evidence with this point in mind.

THE PURPOSE OF CRIME SCENE PHOTOGRAPHS

To Document Crime/Accident Scenes and Evidence

Photographs are one of the basic techniques to document crime/accident scenes. The other techniques are sketches/diagrams and note taking. As a documentation technique, there are three basic categories of crime/accident scene photographs: overalls, midranges, and close-ups. The information in chapter "Crime Scene Photography" will suffice for their explanation.

To Provide Investigative Leads

Photographs are also used throughout the investigation. Other investigators, not present at the original crime/accident scene, can review the original scene photographs to gain an understanding of what happened and then assist with the investigation. Photographs can be shown to a variety of people to identify both the people and objects critical to the particular crime under investigation. Crime scene photographs can be shown to crime scene reconstructionists who were not able to be present during the original crime scene **Processing**; with the proper photographs; these people can aid in the reconstruction of the events of the scene.

To Refresh Memory, Substantiate Testimony, and Clarify Understanding

During the trial, photographs can serve a variety of purposes. When a witness is trying to explain a complicated idea, often a photograph or two may assist in making the point. When the trial is being conducted a long time after the original crime occurred, photographs of the scene can easily and quickly refresh the memory of personnel present at the original scene. If contradictory explanations are being presented about a particular material fact about the scene or the evidence within the scene, photographs can help decide the issue or make it easier to determine who may be telling the truth.

PHOTOGRAPHS OF SUSPECTS AND EVIDENCE

If a crime scene photographer approaches people on the street with a camera in hand, those people may indicate they do not want to be photographed. They may even say that if they are photographed without their permission, they will sue the photographer for infringing on their rights. Is the consent of people being photographed required? What other "rights" might such persons have?

Is Consent Required?

If the persons or objects being photographed are in a public place, available to be viewed by anyone else present, then photographs can be taken by law enforcement personnel, even if those people say they do not want you to photograph them or the objects, which is not true of commercial photographers attempting to take photographs to sell to a variety of publishers. In many jurisdictions there are "model" contracts that would have to be signed by a person being photographed, giving the photographer permission to use the photograph for financial gain. If the photograph is being taken for law enforcement purposes, and not for profit, the rules are different. If the evidence is in a public place, photographs can be taken even if the subjects object to them. If the subjects choose to expose their faces or property in a public venue, anyone around can look at them or their property. If the general public can look at them or their property, then it is also legal to photograph them for law enforcement purposes.

Do Miranda Rights Apply?

Miranda v. Arizona, 384 U.S. 436 (1966), applies to testimonial evidence only. It protects a person against involuntary, compelled self-incrimination, and statements made without the benefit of legal counsel being present. It does not apply to photographs or other aspects of physical evidence. A subject about to be photographed may assert his or her Miranda rights will be violated if the photographer takes a photograph without his or her permission. That person is incorrect.

Trespassing

It is illegal to trespass on the property of others without their permission. If a photographer trespasses on restricted property to get the photograph in question, he or she may be charged with this crime, and the photographs taken from an illegal position may eventually be excluded from court. A person's **Reasonable Expectation of Privacy** can be violated with the proper legal instrument: a search warrant. Without a search warrant, or the consent of the property owner, entering on restricted property puts the photographer in legal jeopardy and will make the resultant photographs inadmissible in court.

Legal flying restrictions exist, such as how close you can fly to the ground in various situations. There have been cases in which law enforcement personnel, when attempting to photograph marijuana fields, has flown over property at illegal heights to recognize and photograph the plant material. If the flying height has been too low, the courts have held the resultant photographs to be a product of an illegal search and have held the photographs to be inadmissible. Fly at the proper height, and get a longer telephoto lens.

Surveillance Photography

Surveillance photographs are frequently taken without the knowledge of the person being photographed. The same rule applies as stated previously: if a person or object is in the public view at a place open to the public, that person can be photographed whether or not he or she knows a photograph is being taken. Even if that person later learns of the photographs, he or she cannot object to them being used as evidence at trial.

If the subject, however, is in a place where he or she normally has a reasonable expectation of privacy, the rules are different. Private places do not fall within the meaning of public places. The public cannot stroll into a private home, even if the front door is unlocked. The courts have protected these and other private places. Items seized after unreasonable searches and seizures from places where a person has a reasonable expectation of privacy will be held to be inadmissible in court.

This expectation of privacy also applies to photographs in/into such places. Photographs of the interior of a home, even if it is a crime scene, cannot be used in court as evidence unless the home owner's reasonable, and legal, expectation of privacy has been legally overcome. This can be done with a search warrant. The search warrant requirement applies to both standing in a subject's living room and taking photographs of a homicide victim there, and it applies to setting up a camera two blocks away with a super-telephoto lens to photograph the people sitting around a dining room table while planning a bank robbery. In both situations, a search warrant would be required. A search warrant is

the legal instrument by which an otherwise legal expectation of privacy can be violated. Therefore, photography that may be deemed to be invasive would require a search warrant.

Even though a person's home is usually regarded as a restricted area for the collection of evidence, limits to this restriction exist. The reasonable expectation of privacy has to be manifested by positive actions. The doors have to be closed and the blinds or drapes have to be drawn. If a nude person walks in front of an unblocked window where anyone on the front sidewalk can easily see him or her, even though that person is in his or her "castle," that person is still exposing himself or herself to the public. If the general public can see that person from the sidewalk, law enforcement personnel can also take enforcement actions and arrest him or her for indecent exposure.

If someone chooses to grow a prize marijuana plant so the light from the front window will nourish it, and it can be seen by any of the public on the front sidewalk, law enforcement eyes can also legally see it and use it for probable cause for a search warrant.

LEGAL IMPLICATIONS OF DIGITAL IMAGING

Despite the fact that digital imaging is quickly becoming the norm for most law enforcement purposes, some agencies may be fearful of making the jump into digital imaging. Just because digital imaging can show dinosaurs roaming isolated islands and can bring to life our old friend Superman, it may not be appropriate for digital images to be offered as evidence in court. No one can deny the marvelous possibilities of the technology. Just because the possibility exists for making the otherwise impossible seem possible, it is not a logical consequence that such "magical" manipulations must be applied to images intended for use as evidence in court. Nuclear energy can be used to construct bombs to kill people. Some nuclear energy provides essential power to cities. It cannot be denied that nuclear energy can be used for both purposes. It is not, however, necessary that all nuclear energy is used for destructive purposes. There can be other, socially acceptable and responsible uses for that technology.

If one use of the technology is deemed to be destructive and "evil," how can anyone be assured every use of the technology is not also destructive and "evil"? The answer is obvious. Set up rules and abide by them.

The same goes for digital imaging. Do not deny that digital images can be manipulated. Of course, the technology makes that a possibility. Assert that despite this possibility, in the context of law enforcement imaging, there will be a clear set of digital procedures that will be acceptable and a clear set of digital procedures that will be unacceptable. Standard operating procedures (SOPs) will be written that clearly point out the manipulations that will be prohibited and the processes that will be permitted. Then, follow your SOPs.

Writing SOPs may feel daunting for some. Others know that assistance is available for generating your agency's SOPs. In fact, the more your agency takes on the role of a "Lone Ranger," working independently from others doing the same thing, the more you set yourself and your agency up for a fall. The more your agency aligns itself with the digital imaging community as a whole, the more likelihood your agency will succeed when digital images are offered to the courts as evidence.

The Scientific Working Group on Imaging Technologies (**SWGIT**) were a group of digital imaging practitioners organized under the umbrella of the FBI to determine the best practices for law enforcement agencies and individuals who use digital imaging as part of their work flow.

Just as there were scientific working groups for other forensic science disciplines, DNA analysts (SWGDAM), latent print examiners (**SWGFAST**), firearms and tool mark examiners (SWGGUN), trace examiners (SWGMAT), questioned document examiners (SWGDOC), just to name a few, crime scene photographers and forensic photographers working in a laboratory environment had SWGIT to represent them. Perhaps SWGIT, itself, best explained its reason for being:

> The Scientific Working Group on Imaging Technologies (SWGIT) was created to provide leadership to the law enforcement community by developing guidelines for good practices for the use of imaging technologies within the criminal justice system.

Recently, The National Institute of Standards and Technology (NIST) is the umbrella under which the Organization of Scientific Area Committees (**OSACs**) are continuing the work of the SWGs. Several of its Subcommittees will have impact on crime scene photography. These are the Subcommittees on Footwear and Tires, Friction Ridges and Digital Evidence. Recently announced is a new Subcommittee on Crime Scene Investigations. The OSACs "will coordinate development of standards and guidelines for the forensic science community to improve quality and consistency of work in the forensic science community." They have begun the process of writing drafts of guidelines which will eventually become the standards by which much of crime scene photography will be standardized.

Background

Although digital imaging technologies have been used in a variety of scientific fields for decades, their application in the criminal justice system has been relatively recent. Consequently, there has been a need to gather and disseminate accurate information regarding the proper application of this and other imaging technologies in the criminal justice system.

Documented Procedures

Personnel engaged in the capture, storage, processing, analysis, transmission, or output of imagery in the criminal justice system should ensure that their use of images and imaging technologies is governed by the documented policies and procedures which the OSAC Subcommittees will eventually produce.

Reinventing the wheel is not necessary. As an individual supervisor tasked with developing your agency's SOPs for implementing digital imaging technology, where do you begin? SWGIT had already done the hard part. The more you comply with the guidelines developed by SWGIT, the more success you will have when challenged in court when you offer digital imaging evidence the defense will be sure to characterize as "demonic, and sure to lead to the downfall of civilization." However, should you choose to reinvent the wheel and develop your own SOPs in a vacuum, the more likely the defense will be successful when attempting to throw suspicion on your work and work products. SWGIT was one bandwagon worth jumping on. And, until the OSACs produce their own guidelines, modeling your procedures on what SWGIT had recommended is the smartest this to do.

A quick synopsis of some of SWGIT's guidelines follows. To be as up-to-date as possible, it is recommended you review SWGIT's (soon to be the OSACs) current guidelines as published on the Internet (http://www.theiai.org/guidelines/swgit/index.php). When this text was first organized, it was thought that appending all of SWGITs guidelines at the end of the textbook would be a valuable resource. As with all things digital, however, there are and will be constant changes and updates to the SWGIT guidelines as they currently exist. Any published list of all the SWGIT guidelines will soon be out of date. But the general flavor will remain.

The following are some of the general recommendations for creating SOPs for your agency.

Manipulations Prohibited

What are digital manipulations? By definition, a **Manipulation** involves either the addition of details that were not in the original image, or the deletion of essential details that were in the original image. Hollywood's creative community thrives on these activities. Manipulations do not belong in a courtroom manifesting themselves in digital images being offered to the court as evidence. Every agency's SOP should contain a clear definition of what a manipulation is, quickly followed by a prohibition of the use of manipulations on digital images destined for the courtroom.

Adding and Deleting Digital Data

Fig. 12.5 shows the range of manipulations that are possible. On the left, the original coin was copied and multiplied to appear in various locations around the original coin. Digital details were added. The license plate image was manipulated by copying the number "0" and then superimposing the "0" over the number "2," which is a combination of adding to



FIGURE 12.5
Manipulations: additions, changes, and deletions.

and deleting details from the same image. The image of the pistol, magazine, and cartridge was manipulated by cloning areas of the carpet and then superimposing carpet over the magazine and cartridge. Digital details were eliminated. None of these kinds of activities are proper with digital images going to court. They would be neither "accurate" renditions of the scene nor "authentic" depictions of the original scene "as found."

Image Capture Choices

When the digital camera is set up to capture images, frequently the crime scene photographer has four choices. You can set your digital camera to capture images in **RAW** (or Nikon's NEF: Nikon Electronic Format), TIFF (Tagged Image File Format), JPEG (Joint Photographic Experts Group), or RAW + JPEG. Are there any general guidelines? If your agency has an SOP on this, follow your agency's SOP. If not, consider these recommendations.

If you are absolutely sure a particular image is not being taken as an examination quality photograph, then JPEG is a suitable choice. When you are taking a JPEG image, it is recommended to use the highest-quality JPEG choice your camera offers. The value of the JPEG format is that the file size will be greatly reduced, allowing more images to be captured on the camera's memory card, your computer's hard drive, and ultimately on some archiving media. The trade-off is that the image's file size will be compressed, which discards digital data that cannot be recovered later. However, this is exactly why using JPEGs is recommended only for images that will not be used for examination quality photographs. Perhaps 80–90% of crime scene images can be captured as JPEG.

Uncompressed RAW or uncompressed TIFF? Both formats *are* recommended for examination quality photographs. A RAW (not an acronym for anything) file, to be precise, is not yet an image: It is an "unprocessed" file. The RAW file will have to be brought into a RAW converter program, where decisions will then have to be made on everything about the image. Actually, most RAW converter programs do use defaults or presets, and if you do not like any of them, you can alter them. Typical choices include brightness, contrast, picture style, saturation, lighting (white balance), noise reduction, sharpness, and lens correction. The RAW format gives the photographer the most control over what the finalized image will look like. Another benefit to the RAW format is that it produces an initial file size smaller than what a TIFF format creates. The reason is that it captures color data in a 12-bit raw channel. TIFFs, on the other hand, create a 24-bit image. The reason is that each color—red, green, and blue—is being captured as an 8-bit color channel, totaling 24 bits. RAW gives you the most choices but also requires the time and effort to make those choices.

An image captured in a TIFF format is processed in the camera before being written to the memory card. It is a viewable image. If you wish to "process" a TIFF image, you will have to bring it into a software program like Photoshop. There, it can be edited. The downside is that it is a very large file, and storing and archiving a multitude of TIFF images will eventually take enormous storage areas.

Newer cameras are offering the option of capturing an image as both a TIFF file and as a JPEG file, giving you multiple options, with the cost of taking up even more storage space.

Compression Choices

Once the image has been captured, you must choose between a variety of **Lossy Compression** formats or **Lossless Compression** formats. Lossy compression formats, like JPEGs, come in a variety of increments, such as Max, Hi, Med, and Low.

These choices allow you to store more images on your media card. To store more images on the same card, some of the data of each image is discarded to make a smaller file size, which is done primarily by two techniques. When many adjacent pixels of the same color or tonal value are present, the JPEG software will discard all but one of the pixels, which will stand as a surrogate for all the discarded pixels. When the compressed file is used to reconstitute the image, that single surrogate pixel will be duplicated everywhere discarded pixels had been. This procedure can drastically reduce file sizes. A second approach to JPEG compression is to take similar, but differently colored or toned adjacent pixels, and average them to arrive at homogenous adjacent pixels. As before, one surrogate pixel can substitute for all the other similar pixels that can now be discarded. Once these digital data are eliminated by a JPEG compression format, the data can never be retrieved again; they are permanently lost.

An alternative to the JPEG compression format is the **LZW** (for the developers, Lempel-ZIV-Welch) TIFF compression format. LZW TIFFs are considered a lossless file format. LZW TIFF compressions reorder the digital data into a smaller file size without deleting any pixels at all. When many similar adjacent pixels are present, such as in the blue sky, similar blues can be reordered like this.

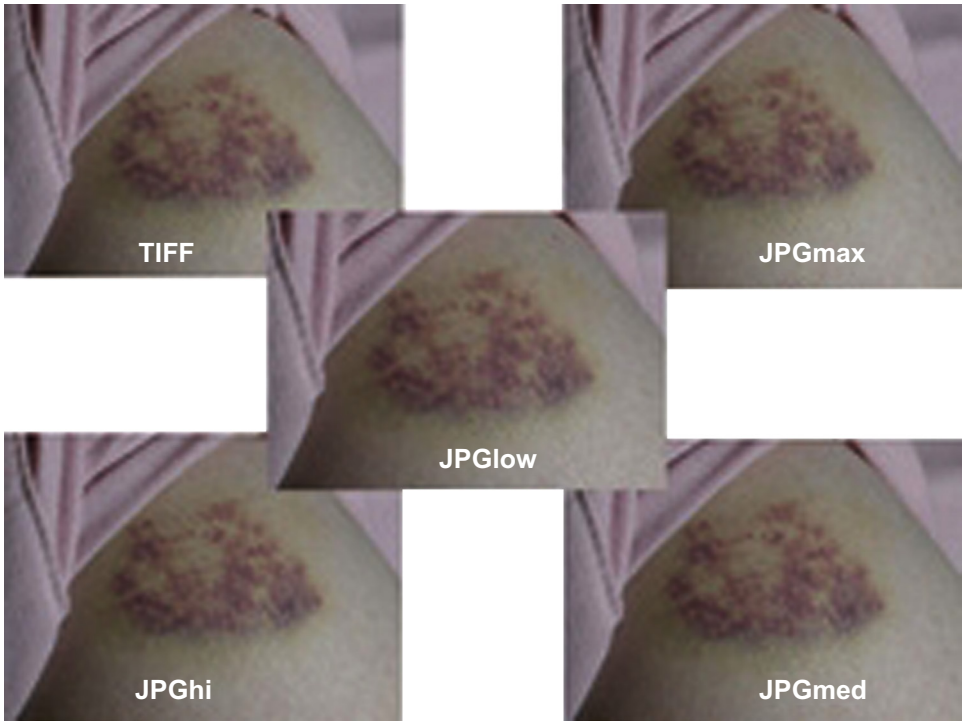


FIGURE 12.6
A bruise with TIFF and JPEG compressions.

A string of 10 exact blues, for example, BBBBBBBBBB, takes up more space than 10×B, which takes up only four spaces on the digital flash card or on the computer hard drive. When the file is used to form a digital image, all the original blue pixels will assume their original locations. Nothing will be lost during compression and the creation of an image from that lossless file.

JPEG compressions are an option only because they do a magnificent job of compressing digital files, usually without any noticeable degradation to the original image. Just because you cannot see a change in the image does not mean no change to the image exists. The distinction between what is proper for the documentary image of the façade of a crime scene and what should be allowable for an examination quality photograph needs to be made. The higher standard applies only to the "critical comparisons" because decisions about the guilt or innocence of a defendant in court should not be based on images that have had part of their original detail discarded, even if "you cannot see the difference."

Fig. 12.6 shows five images of a bruise to an arm. They all look alike, don't they? If they look alike, why all the fuss? Should any of the five images not be able to be used in court as evidence? In this case, it is not what you can see that is important, but it is what you know has happened to the content of the image that is important. When you are writing your agency's SOPs for digital imaging, if it is known any process results in the loss of significant digital data, that process should not be permitted when applied to examination quality images or images considered "critical comparisons." How would you like to have to admit to the judge that the image being offered in court to help convict the defendant has knowingly had much of its digital data discarded by a process you used? Especially when a process is available that does not discard digital data or change it.

Now replace one pixel with a red one and see what happens on the pixel level. Fig. 12.7 demonstrates these changes. Compressing the data with an LZW TIFF format results in the original red pixel being duplicated when the full image is recreated from the compressed file. The Max JPEG reconstitution of the image also looks very good, but an examination of the new file size compared with a TIFF file size of the same image would convince anyone that somewhere data have been lost by capturing the image as JPEG. JPEGs Hi, Med, and Low show obvious changes to the original red pixel. Your agency's SOP should clearly indicate when JPEG compressions are allowable and when only uncompressed TIFF formats should be used to store image files.

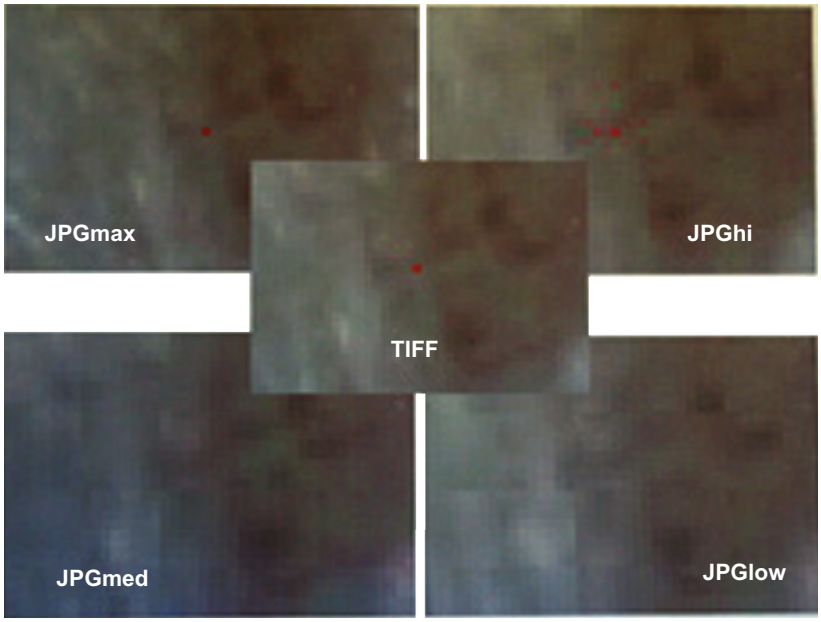


FIGURE 12.7
Bruise shown in Fig. 12.6 enlarged, a single pixel changed to red, and then saved with TIFF and JPG compressions.

A History of Processed Images Should Be Maintained

If manipulations are to be avoided with examination quality images, what digital "changes" are permissible? The term for acceptable "changes" to a digital image is processing.

Before the advent of digital cameras, film cameras captured images on the film in the camera. This film would have to be processed in a wet-chemistry darkroom to produce a print or what everyone knows as a traditional photograph. Film was processed; digital images can also now be processed.

Processing differs from manipulation in this way. Whereas manipulation either adds details that were not originally present or deletes details that were originally present, the essence of processing is to take the essential detail that is in the original image and make it easier to see. Many of the processing techniques in a digital darkroom have analogous techniques in a wet-chemistry darkroom. SWGIT had conveniently arranged these digital processes, which are similar to traditional wet-chemistry processing, into category 1 processes. Much that can now be done with digital images has also been able to be done to film. Many of the film processes are mirrored now with digital processes. In fact, that is exactly why the older term "enhancements" has been changed to "processes." Because the two types of processing are so similar, the digital imaging community wanted to assure the public of this heritage and reassert that much digital processing is merely updated digital versions of what has been commonly accepted with film processing.

Digital imaging technology has advanced the art of improving an otherwise marginal image. Category 2 processes are on an additional list. Their purpose is the same: to improve the visibility of the essential details in the image. However, these techniques do not have a clear-cut heritage in the wet-chemistry darkroom. Category 2 processing is also considered an "advanced" processing technique. At the end of a category 2 processing, the resulting image may not look similar to the original image. In anticipation of the wailing to come from the defense side of the court, strategies have been developed to ensure even these processes will ultimately be acceptable to the courts. The goal? It is to ensure the court that the resultant images are in fact improvements of the essential details already contained in the original image. The tactic? Make sure the entire process is **Repeatable** by any other specialist in the field of digital imaging, be that another law enforcement digital imaging expert, a prosecutor's digital imaging expert, or even the defense's digital imaging expert.

If it is ever asserted by any expert that he or she is the only one who is gifted enough to be able to effect the necessary identification, red flags should immediately come up. An identification that can be made only by one person is worthless. Unless it can be verified by other equally competent peers in the relevant scientific community, any identification should be suspect. If only one imaging analyst can produce the processed image necessary for comparison purposes, it, too, should be viewed with skepticism. Only when digital imaging processes can be achieved by a variety of competent digital imaging experts should the courts feel comfortable the processing is legitimate and a commonly acceptable practice in the relevant community.

To ensure the courts that no "magic" is being done to the original image or that no substitution of one image for another is taking place, a precise history of all "changes" done to the image must be recorded and be able to be presented to the court should the court wish to have the repeatability of the process demonstrated.

A clarification is warranted here. Under circumstances in which a particular digitally processed image has been challenged, it may be necessary that another expert follow the precise history of all the steps taken by the initial analyst who produced the first processed image. It can then be said that the initial processing steps are repeatable by any other competent expert to assure the court the processed image did, in fact, come from the original image from the crime scene.

Another meaning of "repeatable" has sometimes been confused with this first meaning. When an identification has been made by one examiner, it is then necessary that the identification be verified by a second examiner. The second examiner then begins a new examination from scratch and may frequently use entirely different aspects of the evidence to establish the first identification is warranted. The first identification has been "repeated" by the second examiner, but the second examiner has made an independent examination of the evidence and has not just reconsidered the same aspects of the evidence as the first examiner. The original identification has been verified or repeated. The exact steps used by the first examiner were not necessarily repeated.

Who Did the Processing and When?

As with any other processing of evidence, a record must be kept as to who had access to the digital evidence, which is a standard chain of custody requirement. Critical evidence must not be left in an open place where it is accessible by any without legitimate access to the evidence. If access to the evidence is not carefully managed, the defense can question whether inappropriate personnel gained access and changed or altered the evidence in some way. There should be restricted access to the room in which the computer with digital files is maintained. The computer housing the evidence should record who accessed the computer. The computer can require an authorized password to activate the software. A log of who accessed the digital evidence and when must be maintained and routinely checked by a supervisor.

Types of Processing

Detailed notes must be kept as to the exact kind of advanced digital imaging processing that was done to the image. Some software automatically records any changes to the image and adds this information to the metadata in the image file. Otherwise, written notes have to be maintained so that, if challenged, another expert can apply the same sort of processes to the image.

Amount/Degree of Processing

In addition to the type of processing applied to any particular image, the amount of the processing technique must also be maintained and recorded. Most digital imaging techniques have a numerical increment of the process that is also indicated in the software. These numerical values must also be recorded. Only if this is done can any other competent expert come in to duplicate the changes made during the original processing.

Training/Competency and Proficiency Tests

Only personnel properly trained to competency should be performing category 2 processes on evidence images. A complete training record must be maintained on all personnel deemed digital imaging experts. As with all crime laboratory specialists, each digital imaging specialist/examiner should also have to successfully complete a proficiency examination.

Originals Archived; Processing Only Applied to Copies

A film negative was the "original" evidence. Individual prints were processed to have more or less contrast or to filter out improper color tints. Individual prints were burned and dodged when more or less light was required in selected areas of the image. The negative, however, was never changed.

One of SWGIT's last documents, "Best Practices for Archiving Digital and Multimedia Evidence (DME) in the Criminal Justice System," indicates that "(a)rchiving is the process of storing data in a manner suitable for long-term availability and retrieval" (http://www.theiai.org/guidelines/swgit/index.php). SWGIT continued by indicating that "it may be necessary to retain original software and hardware, or to transfer data from one type of media to another, in order to access archived DME in the future." This statement acknowledges two issues. First, although current media for the

storage of digital data frequently claim a long lifespan, it is recognized that, in fact, current storage media have only a limited lifespan. Today's optical media, CDs and DVDs, should not be anticipated to last as long as a jurisdiction's legal obligation to store digital evidence. It, therefore, becomes necessary to assure the media is still serviceable "by periodically testing and refreshing as required." This means copying the original digital data onto new media. This new media may mean a new version of the original media, or if the technology has evolved substantially, it will mean copying the original data to the future state-of-the-art media.

Most are aware that digital hardware and software are constantly evolving. By the time the digital evidence becomes needed at some future date, this original hardware and software may be considered old technology. However, it may be necessary to maintain the hardware and software that originally produced and stored the evidence. In addition, in recognition of the fact that the original hardware and software may become obsolete, it will be necessary to transfer copies of the original evidence to the new "standards" of hardware. Besides CDs and DVDs, digital data may also be stored on magnetic tape and servers, which may or may not include redundant arrays of independent disks (RAIDs).

As a precaution, it is recommended to maintain multiple archival originals. The digital data ought to be archived on separate hardware, maintained at separate sites. Damage to and/or failure of one of the archived originals, then, does not prevent access to the evidence.

If the digital evidence requires processing, this should be performed only on copies of the archived original. The original digital evidence must never be altered.

These are the minimal recommendations SWGIT suggested should be included in an agency's SOPs related to processing digital imaging. It is suggested you view the actual SWGIT documents and guidelines still available on the Internet. Updates and changes to these documents by the OSACs are inevitable, and you must view the most recent documents to be assured of full compliance with SWGIT/OSAC recommendations, which is extremely important. In one recent court case, the judge made it clear the processed digital image was acceptable in his court as evidence simply because the processing of the image had closely followed SWGIT guidelines. The more you can cloak yourself and your agency under the SWGIT/OSAC umbrella, the more likely your processed digital images will be accepted into court as evidence.

INTERNATIONAL ASSOCIATION FOR IDENTIFICATION RESOLUTION 97-9

Defense attorneys are famous for overstating or understating the facts, if doing so suits a position they are currently advocating. Many may try to assert that digital imaging is such a new technology that it cannot meet Frye standards of being generally accepted in the relevant scientific community. Here is one more tidbit you might keep in your back pocket if this is ever mentioned in court. In 1997, the International Association for Identification (IAI) adopted Resolution 97-9. In that resolution, the IAI "recognized digital imaging as a scientifically valid and proven technology."

The IAI, by the way, is the body that certifies forensic photographers and crime scene photographers, besides latent print examiners, crime scene analysts, forensic artists, and blood spatter analysts. It is to be expected that becoming certified in the field will be another criterion by which a judge can decide that digital imaging has been properly done. Follow SWGIT guidelines and become an IAI certified crime scene photographer and/or a forensic photographer. The National Academy of Science (NAS) in 2003 published multiple recommendations for the improvement of the forensic sciences. One of those recommendations was the certification of individuals in the field of forensic science. Of course, agencies need to be accredited; now it is recognized that it is just as important to certify individuals.

New Case Law Citations Since Second Edition

Case law citations from the second edition have been removed from this addition and stored in the Companion Website (http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780128027646).

TIME FRAME

State v. Alzaga, 2015 UT App. 133, 352 P.3d 107 (Utah Ct. App. 2015)

Defendant appealed a conviction for murder, aggravated assault, and aggravated robbery. Among other things, it was argued that it was an abuse of discretion to admit crime scene photos taken in a different season than the crime. The photographs were deemed relevant, nonprejudicial, and authenticated. If a competent witness with personal knowledge of the facts represented by a photograph testifies that the photograph accurately reflects those facts, it is admissible. Judgment was affirmed.

Shea v. Kevic Corp., 156 Idaho 540, 328 P.3d 520 (2014)

A car wash owner was granted summary judgment when a customer claimed that she was injured when she slipped and fell on ice near the exit of the car wash due to the owner's negligence in allowing ice to build up near the car wash exit or in failing to warn of the danger of ice buildup. Photographs are generally admissible when the witness who identifies them testifies that they correctly portray relevant scenes or objects. Changes in the conditions portrayed between the time of the event under investigation and the taking of a photograph do not render the photograph inadmissible if the changes can be explained by a witness, and if the changes are not of such a character as to render the photograph deceptive. The district court erred in granting summary judgment to the owner because the customer showed the existence of genuine issues of material fact. Judgment of dismissal vacated, and case remanded for further proceedings.

"A FAIR AND ACCURATE REPRESENTATION OF THE SCENE"

Pena v. State, 467 S.W.3d 71 (Tex. App. San Antonio 2015)

This case stems from Appellant's convictions of the offenses of aggravated sexual assault and indecency with a child. Court did not err in admitting a photograph during the punishment phase; the photograph was properly authenticated because the photograph proffered with the testimony regarding the exchange of messages and photographs circumstantially supported that the messages were sent by Defendant. When a photograph is authenticated by a witness with knowledge, the admissibility of the photograph is conditioned on the witness's identification of the exhibit as a fair and accurate depiction of the event the photograph purports to portray; there is no requirement the individual authenticating the photograph have been the photographer or even been present when the photograph was taken. Judgment affirmed.

State v. Leavitt, 2015 ND 146, 864 N.W.2d 472 (N.D. 2015)

Defendant appealed an attempted murder conviction. It was argued that there was abuse of discretion in admitting an altered photograph where the original photograph was entered into evidence without objection, a ruler provided reference to the size of a footprint in both photographs, and there was testimony about the training received and the process used to alter the image. Trial court acted within its discretion in admitting photograph of bloody footprint taken from inside victim's home, which was cropped, colored, and resized by administrative clerk for investigations division of police department, where original photograph was entered into evidence without objection, a ruler to provide reference to size of footprint was in both photographs, and clerk testified that she received training in particular program she used and regarding process she used to alter the image. Judgment affirmed.

People v. Barcero, 116 A.D.3d 1060, 984 N.Y.S.2d 419 (2d Dep't 2014)

Defendant appealed convictions for attempted burglary in the second degree and possession of burglar tools, and burglary in the second degree, grand larceny in the third degree, and criminal mischief in the fourth degree. The Defendant's contention that the Supreme Court improperly denied the admission into evidence of a certain photograph of a basement window at the home where the attempted burglary occurred is without merit. The Defendant failed to establish a proper foundation by showing that it was a fair and accurate representation of the window on the date of the incident. Judgment affirmed.

Sharbono v. Hilborn, 2014 IL App (3d) 120597, 382 Ill. Dec. 251, 12 N.E.3d 530 (App. Ct. 3d Dist. 2014)

The case involved a malpractice claim. Plaintiff claimed a breach in the standard of care regarding a diagnosis that a lesion in her left breast was benign. The trial court erred in allowing the defense to present a computer presentation as demonstrative evidence during the radiologist's testimony because, without the proper foundation, the use of the conclusory images to show the basis of his medical opinion was highly prejudicial as it went to the heart of the malpractice claim, that he failed to correctly interpret the patient's 2004 breast lesion images as malignant. If the demonstrative evidence that the proponent seeks to admit is a filmed or photographed image, to establish the necessary foundation, the proponent must have a witness with personal knowledge of the filmed or photographed object testify that the film or image is an accurate portrayal of what it purports to show, unless, of course, the parties have made a stipulation to that effect. Judgment reversed and remanded.

DiNardo Seaside Tower, Ltd. v. Sikorsky Aircraft Corp., 153 Conn. App. 10, 100 A.3d 413 (2014)

Tenant was granted a directed verdict in an industrial landlord's claim. Landlord appealed. The trial court's decision not to admit photographs into evidence was not an abuse of discretion because the prejudicial impact of them, depicting red tape, outweighed their probative value. A photograph offered to prove the appearance of something which cannot itself be inspected by the jury must first be proved accurate. Judgment affirmed.

Watson v. State, 421 S.W.3d 186 (Tex. App. San Antonio 2013)

Defendant appealed drug conviction, arguing against admittance of photograph and silent videotape. The predicate to introduce a photograph and a silent videotape not accompanied by sound need not be laid by the photographer, the individual being photographed, or even a person present in the photograph in question; any witness observing the scene depicted in the photograph may lay the predicate so long as the witness can provide testimony based on personal knowledge, sufficient to support a finding that the matter in question is what its proponent claims. Because the audio on the recording was muted, there was no in-court testimony by the informant, and criminal code requiring corroboration of accomplice testimony was not applicable. Judgment affirmed.

People v. Green, 107 A.D.3d 915, 967 N.Y.S.2d 753 (2d Dep't 2013)

This case was an appeal by the Defendant from a conviction for burglary in the first degree, rape in the first degree, unlawful imprisonment in the first degree, and menacing in the second degree, upon a jury verdict, and imposing sentence. Defendant's testimony that photographs of text messages were actual photographs of screen of her telephone, and that she saw detective taking photographs, was sufficient to establish that text messages had been accurately and fairly reproduced, thereby providing foundation for admission of photographs in rape prosecution. Judgment was affirmed.

State v. Rabindranauth, 140 Conn. App. 122, 58 A.3d 361 (2013)

Defendant appealed his conviction for murder. Copy of photograph allegedly from victim's page on social network site depicting someone wearing mask and holding weapons was not verified as showing that person in photograph was victim, which Defendant offered to support his claim that he shot victim in self-defense, in trial for murder; photograph was grainy, distorted and most of subject's face was covered, photograph did not have any features that identified it as being from social network's website or victim's page on website, original image was not available at trial, and nothing was established as to whom photograph depicted. Defendant could not prevail on his claim that the trial court improperly failed to admit into evidence a copy of this photograph. Judgment was affirmed.

Boyle v. State, 154 So.3d 171 (Ala. Crim. App. 2013)

Defendant was properly convicted of capital murder of a two-year-old and possessing a controlled substance. Photographic evidence was not challenged. To be admissible, the photographic material must be a true and accurate representation of the subject that it purports to represent. Judgment affirmed.

Rushing v. Com. 284 Va. 270, 726 S.E.2d 333 (2012)

After a jury trial, Defendant was convicted of participation in a criminal street, aggravated malicious wounding, use of a firearm while committing aggravated malicious wounding, burglary while armed, and use of a firearm while committing burglary. He appealed; the Court of Appeals of Virginia affirmed. He sought further review. A detective opined the two were gang members based on their joint participation in the burglary and an unauthenticated photo of Defendant making a purported gang hand signal. The photographer did not testify, nor did any witness identify the photograph as a fair representation of the scene it portrayed or describe the circumstances existing when it was taken. The high court reversed and dismissed Defendant's convictions for gang participation and for use of a firearm in the commission of burglary; his other convictions were unaffected.

State v. Joseph, 426 N.J Super. 204, 43 A.3d 1233 (App. Div. 2012)

Defendant appealed conviction for three armed robberies, as well as other crimes, following a jury trial. Defendant challenged the computerized photograph database used by the police wherein three victims of the robberies made an identification of him. Defendant asserted that the scientific reliability of the photo retrieval system used to obtain the out-of-court identifications in his case had to be established by expert testimony. The court disagreed and held that the system was not newly devised or novel technology and routinely accepted by courts. As such, a judgment about the system could be made without the need for expert testimony. The court held that a proper foundation was laid for the computer-based photo retrieval system used to obtain the three victims' out-of-court identifications and that such a procedure, akin to a mug shot book, was not invalidated by police failure to record and retain the photographs viewed by the witnesses. The court remanded the case to the trial court for resentencing to reflect the appropriate merger and unmerger of offenses and to amend the judgment of conviction accordingly. Otherwise, the court affirmed the judgment of conviction in all other respects.

Johnson v. Bailey, 2012 IL App (3d) 110016, 359 Ill. Dec 931, 967 N.E.2d 961 (App. Ct. 3d Dist. 2012)

Plaintiff brought a negligence action against Defendant to recover for personal injuries she alleged to have sustained as a result of an automobile accident in which she and Defendant were involved. Jury found in favor of Defendant and Plaintiff appealed. The court found that a postoccurrence photograph of a parking lot where the accident occurred should have been precluded because it lacked an adequate foundation and was also misleading. The failure to adequately represent the location of plaintiff's vehicle as depicted in the photograph prejudiced plaintiff. The prejudice resulted even though plaintiff had a chance to demonstrate on the photographs where she believed her vehicle was located prior to the accident. Before a photograph may be admitted, a proper foundation must be offered establishing: (1) the photo is a true and accurate representation of what it purports to portray; and (2) the subject of the photo was in substantially the same condition it was in at the time of the accident. The judgment was reversed, and the case was remanded.

Com. v. Rogers, 459 Mass. 249, 945 N.E.2d 295 (2011)

This case was an appeal of a felony-murder, assault and battery conviction, arguing improper jury instruction. Photographic evidence was not challenged. When demonstrative photograph is generated as a digital image or video image, the judge must determine whether the image fairly and accurately presents what it purports to be, whether it is relevant, and whether its probative value outweighs any prejudice to the other party; concerns regarding the completeness or production of the image go to its weight and not its admissibility. The Court affirmed the judgment.

Washington v. State, 311 Ga. App. 199, 715 S.E.2d 495 (2011)

Defendant appealed his convictions for burglary and carrying a concealed weapon. He argued that the trial court erred in admitting a photograph and that the evidence does not support the convictions. Photograph of recovered items that were allegedly taken in burglary was authenticated by a showing that it was a fair and truthful representation of what it purported to depict, thus rendering photograph admissible at trial; one of the officers who participated in the search of the neighboring apartment, where the items were discovered, testified that the photograph was a fair and accurate description of what he had observed. The Court affirmed the decision.

Jackson v. State, 309 Ga. App. 796, 714 S.E.2d 584

Defendant appealed a conviction on robbery and assault charges. It was argued that the State failed to produce a written witness statement in violation of Brady. Photographic evidence used at trial was not challenged. A party lays a foundation for a photograph by showing that it fairly and accurately represents the object, scene, or person depicted. Any witness familiar with the subject depicted can authenticate a photograph; the witness need not be the photographer nor have been present when the photograph was taken. The court of appeals reversed Defendant's conviction and remanded the case for a new trial.

State v. Hayden, 90 Wn. App. 100, 950 P.2d 1024, 1998 Wash. App. LEXIS 229

- Followed by State v. Hartman, 93 Ohio St. 3d 274, 2001 Ohio 1580, 754 N.E.2d 1150, 2001 Ohio LEXIS 2594

Defendant challenged the admission of digitally enhanced fingerprint evidence. First, Defendant claimed that the state's fingerprint expert lacked the necessary expert qualifications to testify regarding such evidence. Second, Defendant attacked the reliability of digitally enhanced fingerprint evidence. A fingerprint examiner from the sheriff's office testified that by using digitally enhanced imaging, he concluded that a fingerprint found on the bedspread was Defendant's fingerprint. The fingerprints were also compared without using digitally enhanced imaging and the same conclusion reached. Defendant did not challenge the expert credentials as a general latent fingerprint examiner or the identification of Defendant's print on the bedspread by traditional comparison of the prints. Moreover, the trial court properly admitted the expert opinion on digitally enhanced fingerprint evidence. Defense counsel did point out to the judge that the testimony was "blazing new ground" and that the scientific reliability of the digital enhancement method had not been established. The trial court accepted the reliability of digitally enhanced fingerprint evidence based on four factors to be considered in evaluating reliability of scientific evidence: (1) the theory or technique had been tested, (2) it had been subjected to peer review, (3) there was a known or potential rate of error, and (4) the methodology had gained general acceptance. The *Hayden* court considered expert testimony, articles from forensic journals, and other matter in concluding that evidence obtained through digital imaging enhancement of latent fingerprints

is "generally accepted in the relevant scientific community." *Hayden*'s conclusion that digitally enhanced fingerprint evidence was admissible under the more stringent Frye standard supported the conclusion that digitally enhanced fingerprint evidence meet reliability standard. Judgment affirmed.

United States v. Garvin, 88 Fed. Appx 542 (Pa. 2004)

- Followed by United States v. Ware, 2013 U.S. Dist. LEXIS 170536 (E.D. Pa. Dec 2, 2013)

This case was about a nighttime robbery in which only daylight photos were presented. First, petitioners contended that trial counsel was ineffective for failing to object to the government's introduction of crime-scene photographs, which were taken during daylight hours, even though the crime took place at night. The Court concluded that there was no prejudice to petitioners because the jury was made aware of the limited import of the government's daylight photographs. Second, petitioners argued counsel was ineffective for failing to investigate the scene and obtain nighttime pictures of their own to introduce. The relevant question was "whether counsel exercised reasonable professional judgment" in deciding not to obtain such photographs. The Court concluded that counsel exercised "reasonable professional judgment" in deciding to appeal to the jury's common sense rather than introduce their own nighttime photographs of the crime scene.

People v. Perez, 2003 WL 22683442—Unpublished/noncitable November 14, 2003

On multiple contentions, Defendant appealed convictions for burglary, and two counts of hit and run driving. Among other evidence in the burglary case, was a shoe print the People deemed to be that of the Defendant. Upon arrival at the crime scene, officers found the front door had been kicked in and was open. They noticed one shoe print on the surface of the door. At trial, criminalist testified he analyzed shoe print, making initial shoe print comparison using the photograph taken by detective at the scene, and the tennis shoes recovered from Defendant. Testimony indicated he was unable to make the determination that the shoe print was from the actual bottom of Defendant's tennis shoe. Criminalist then used Adobe Photoshop to digitally enhance the image of the shoe print. He did not alter the image in any way. The image enhancement enabled him to see unique characteristics of the shoe print and determined the shoe print on the door came from Defendant's tennis shoe to the exclusion of all other shoes. Judgment affirmed.

AUTHENTIC

Shiozawa v. Duke, 2015 UT App. 40, 344 P.3d 1174 (Utah Ct. App. 2015)

This case involved home buyers bringing action against sellers for fraud and contract claims. Summary judgment was granted to sellers on the fraud claims, was granter to buyers on the contract claims. Numerous photographs were submitted as evidence depicting different images of damage on different dates. Defendants argue that photographs offered by Plaintiffs do not create an issue of fact, because they were not properly authenticated and are thus inadmissible. If a competent witness with personal knowledge of the facts represented by a photograph testifies that the photograph accurately reflects those facts, it is admissible as properly authenticated. The Court agreed with Plaintiffs that the photographs provide support for Plaintiffs' opposition to Defendants' summary judgment motion. Order affirmed in part, reversed in part, and matter remanded.

People v. Macias, 2015 IL App. (1st) 132039, 36 N.E.3d 373 (Ill. App. Ct. 1st Dist. 2015)

Defendant appealed a conviction for first-degree murder. It was argued, among other things, that the trial court admitted prejudicial photographs from a MySpace page without proper foundation or authentication. MySpace photographs were not used as evidence of guilt, as testimony showed that Defendant was not considered a suspect based on the photographs; the photographs were relevant to show the course of the investigation, which led to a co-Defendant, who later implicated Defendant. Photographs of co-Defendant and victim obtained from social media website were sufficiently authenticated, as required to be admissible at murder trial; victim's brother testified that he had obtained access to the photographs from the account of a friend of his cousin, establishing that photographs were what they were claimed to be, which was something used by police during their investigation to identify suspects, not to establish guilt. Judgment affirmed.

State v. Sapp, 182 Wash. App. 910, 322 P.3d 1058 (Div. 3 2014)

Defendant appealed conviction for five counts of felony communication with a minor for immoral purposes, two counts of sexual exploitation of a minor, two counts of first-degree rape of a child, and two counts of first-degree child molestation. Photographic and video recording evidence was sufficiently authenticated to be admitted into evidence. In a case involving sexual offenses against a minor child, a grandmother was able to authenticate photographs and

video recordings because she identified the individuals in the exhibits, the victim's approximate age, and the location depicted in the exhibits. Witness who is providing testimony to authenticate a photograph does not necessarily need to be the photographer. The Court affirms the judgment.

State v. Gray, 758 S.E.2d 699 (N.C. Ct. App. 2014)

Defendant appealed convictions for attempted robbery, conspiracy to commit robbery with a dangerous weapon, and first-degree burglary. Defendant argued that the trial court erred in allowing the photographs of the text messages to be admitted into evidence. Photographs of text messages on arrestee's cellular telephone were properly authenticated in prosecution for attempted robbery and burglary; officer testified that he took the pictures of the text messages, officer identified photographs as screen shots of arrestee's cell phone and testified that they were in substantially the same condition as when he obtained them, and witness with whom arrestee was communicating testified to the authenticity of photographs and identified them as the text message conversation she was having with arrestee. No error found and judgment affirmed.

State v. Williams, 299 Kan. 509, 324 P.3d 1078 (2014)

Defendant appealed conviction for premeditated first-degree murder; conspiracy to commit first-degree murder; and criminal possession of a firearm. Included in multiple arguments was whether the trial court erred in admitting a demonstrative photograph. Generally, in determining whether demonstrative photographs should be admitted, a trial court must determine whether they are relevant and whether a proper foundation has been laid. A proper foundation exists when the witness demonstrates he or she possesses the requisite skill and experience to conduct the demonstration and displays the accuracy and reliability of the models and photographs. With regard to a photograph of a reconstructed scene, the proper test is whether the conditions are the same or substantially similar to the events depicted. Minor differences go to the weight of the evidence rather than its admissibility. The question of what constitutes a permissible variation depends on whether it tends to confuse or mislead the jury. A trial court has broad discretion when making these determinations, and the court's decision to admit such photographs must be accepted on appellate review absent a showing of abuse of discretion. Photographic evidence of reconstructed events is admissible as long as a proper foundation is laid and any discrepancies between the reconstruction and the original event are explained. Judgment affirmed.

People v. Flores, 2014 IL App (1st) 121786, 387 Ill. Dec. 56, 21 N.E.3d 1227 (App. Ct. 1st Dist. 2014)

Defendant appealed convictions for first-degree murder of one man and the attempted murder and aggravated battery with a firearm of a second man during a gang-related incident. Photographs of Defendant and victim obtained from a social media website were sufficiently authenticated, as required to be admissible at murder trial, where victim's brother testified that he had obtained access to the photographs from the account of a friend of his cousin; testimony authenticated that the photographs were what they were claimed to be, something used by the police during their investigation to identify Defendant as a suspect. The prejudicial captions were not admissible in view of the State's inability to show who wrote the captions. In addition, a mug shot of defendant was not admissible because such evidence tends to inform the jury of defendant's unrelated criminal activity. Judgment reversed and remanded due to Defendant's invocation of his right to remain silent not being scrupulously honored.

People v. Peyton, 229 Cal. App. 4th 1063, 177 Cal. Rptr.3d 823 (2d Dist. 2014)

Defendant appealed conviction for receiving stolen property and identify theft. Photos generated by a bank ATM of a withdrawal made with the victim's stolen ATM card were properly received as a business record. Moreover, because an ATM machine cannot be cross-examined, the receipt of machine-generated ATM photos into evidence does not violate the confrontation clause. Judgment affirmed.

People v. Lucas, 60 Cal. 4th 153, 177 Cal. Rptr.3d 378, 333 P.3d 587 (2014)

A jury found Defendant guilty of three counts of first-degree murder, one count of attempted murder and two counts of kidnapping. The jury also found that Defendant personally used a knife during each crime and that he inflicted great bodily injury upon two of the victims. The jury further found true the special circumstance allegation of multiple murder. The jury acquitted Defendant of one murder count and was unable to reach verdicts on two other murder counts. Trial court's finding that photographs of note found at murder scene were sufficiently authenticated to be what the prosecution claimed them to be, in allowing the prosecution to show them to the jury was supported by substantial evidence, including testimony of a police detective and the police lab technician who took the photographs. Judgment affirmed.

People v. Goldsmith, 59 Cal. 4th 258, 172 Cal. Rptr.3d 637, 326 P.3d 239 (2014)

Defendant appealed conviction for failing to stop at a red traffic light. The Supreme Court concluded that the trial court did not err in admitting the ATES evidence over defense objections. The ATES evidence was offered as substantive proof of Defendant's violation, not as demonstrative evidence supporting the testimony of a percipient witness to her alleged violation. The presumptions of authenticity supported a finding, in the absence of contrary evidence, that the printed versions of ATES images and data were accurate representations of the images and data stored in the ATES equipment. Sufficient evidence was submitted to the trial court to sustain a finding that the ATES evidence was the writing that the prosecution claimed it was. The testimony of a witness with special expertise in the operation and maintenance of the ATES computers was not required as a prerequisite for authentication of the ATES evidence. The Court affirmed.

People v. Chism, 58 Cal. 4th 1266, 171 Cal. Rptr.3d 347, 324 P.3d 183 (2014)

Defendant appealed first-degree murder, attempted robbery, and second-degree robbery convictions. Still photographs of murder suspects printed from security camera videotape using videocassette recorder were adequately authenticated by police officer's testimony that the videotape from which the photographs were printed accurately depicted her conduct and that of other people in the store immediately after the shooting, and by a police officer who watched the photographs being printed, even though the top and bottom portions of the photographs showed parts of the image that had not been visible in photographs printed earlier using different equipment. The trial court was directed to modify the abstract of judgment to reflect that Defendant was entitled to 96 days of conduct credit. In all other respects, including the verdict of death, the judgment was affirmed.

Mould v. NJG Food Service Inc., 37 F. Supp.3d 762 (D. Md. 2014)

Plaintiff brought suit against employer on multiple counts. Plaintiff's statement, that proffered exhibit contained true and correct copies of photographs employee obtained from social networking websites, was insufficient to authenticate photographs as substantially correct representations of the behavior they purported to represent, as required for photographs to be admissible evidence at trial against employer for wage and hour violations. Plaintiff's motion was granted in part and denied in part.

State v. Pruitt, 415 S.W.3d 180 (Tenn. 2013)

Defendant appealed conviction for first-degree felony murder committed during the perpetration of a robbery. Photographic evidence was not challenged. All of the medical testimony reflected that the victim died as a result of the injuries sustained during the attack. A photograph must be verified and authenticated by a witness with knowledge of the facts before it can be admitted into evidence. Judgment affirmed.

State v. Murray, 746 S.E.2d 452 (N.C. Ct. App. 2013)

Defendant appealed convictions of possession with intent to sell and deliver cocaine and sale of cocaine, challenging, among other things, the authentication and relevancy of photographs admitted into evidence. A confidential informant's testimony was sufficient to authenticate two of the photographs as people from whom he had purchased drugs and the third photograph as Defendant, such that it was properly admitted. However, a police detective's testimony was not sufficient to authenticate the two photographs as depicting Defendant's sons; the trial court erred by admitting the two photographs as substantive evidence; there was a reasonable possibility that, had the two photographs not been admitted as substantial evidence, a different result would have been reached at the trial. Defendant granted a new trial.

People v. Woodworth, 11 A.D.3d 1368, 976 N.Y.S.2d 631 (4th Dep't 2013)

Defendant appealed a conviction for sexual abuse in the first-degree and multiple other charges.

Defendant argued that the court improperly admitted in evidence photographs that had been enhanced by the People. At trial, the People laid a proper foundation by authenticating the photographs. Additionally, the photographs were relevant with respect to the nature and extent of the victim's injuries, and their sole purpose was not "to arouse the emotions of the jury and to prejudice…Defendant." Photographs that had been enhanced by prosecutor were properly admitted into evidence in prosecution for sexual abuse and other related charges, where prosecutor laid a proper foundation by authenticating the photographs, photographs were relevant with respect to the nature and extent of the victim's injuries, and their sole purpose was not to arouse the emotions of the jury and to prejudice Defendant. Judgment was affirmed.

Luster ex rel. Gusman, Estate of v. Mardi Gras Casino Corp., 121 So.3d 962 (Miss. Ct. App. 2013)

This case was about whether or not a trial court erred by granting summary judgment to a casino because genuine issues of material facts existed as to the casino's alleged negligence in allowing for a dangerous condition to exist on its premises. The trial court properly did not enter photographs of the casino floor into evidence because they were not properly authenticated, as there was no evidence or testimony as to who took the photographs, when the photographs were taken, or where the photographs were taken. Notations written on the photographs were inadmissible hearsay. Judgment was affirmed.

Rushing v. Com. 284 Va. 270, 726 S.E.2d 333 (2012)

After a jury trial, Defendant was convicted of participation in a criminal street, aggravated malicious wounding, use of a firearm while committing aggravated malicious wounding, burglary while armed, and use of a firearm while committing burglary. He appealed; the Court of Appeals of Virginia affirmed. He sought further review. A detective opined the two were gang members based on their joint participation in the burglary and an unauthenticated photo of Defendant making a purported gang hand signal. The photographer did not testify, nor did any witness identify the photograph as a fair representation of the scene it portrayed or describe the circumstances existing when it was taken. The high court reversed and dismissed Defendant's convictions for gang participation and for use of a firearm in the commission of burglary; his other convictions were unaffected.

Brown v. State, 381 S.W.3d 565 (Tex. App. Eastland 2012)

Defendant appealed a judgment of the 35th District Court, Brown County, Texas, convicting him of continuous sexual abuse of a young child. Photographic evidence was not challenged. As general rule, a photograph is admissible if verbal testimony about the matters shown in the photograph is admissible. The judgment was affirmed.

State Farm Mut. Auto. Ins. Co. v. Anders, 197 Ohio App. 3d 22, 2012-Ohio-824, 965 N.E.2d 1056 (10th Dist. Franklin County 2012)

Appellants, a driver and his employer, sought review of the judgment which found in favor of appellee insurer in the insurer's action to recover moneys paid on behalf of its insured as the result of a motor vehicle accident involving the insured and the driver. The trial court did not err in admitting the facility's photographs as the photographs were properly authenticated through the testimony of the insured and the inspector. The insured testified that the photos depicted his vehicle as it appeared after the accident, and the inspector identified the photographs not taken at the scene of the accident as photographs taken by the facility and uploaded to the insurer, as required by the facility's select service facility agreement, in the normal course of the insured's claim-handling process. The Court affirmed the judgment of the trial court.

People v. Goldsmith, 138 Cal. Rptr.3d 305 (Cal. App. 2d Dist. 2012)

This case involved a conviction for failing to stop at a red light at an intersection. Photographic evidence was challenged on multiple levels. Although Defendant challenged the admission into evidence of computer-generated photographs and a video of her traffic violation as unsupported by evidence that the computer operated properly, the court held that testimony on the accuracy and reliability of computer hardware and software is not required as a prerequisite to admission of computer records. Moreover, the photographs and the video were not hearsay, the hearsay rule did not require their exclusion from evidence, and therefore no hearsay exception was necessary to admit the evidence. The photographs and the video were not verbal expression because they did not contain words. The Court affirmed the judgment.

People v. Borzakian, 136 Cal. Rptr.3d 772 (Cal. App. 2d Dist. 2012)

Defendant appealed conviction for failing to stop at a red light signal equipped with an automated red light enforcement system. The People's case was presented through the testimony of a police officer and the automated enforcement evidence, comprised of three photographs with data box text, maintenance logs, a certificate of mailing and notice to appear. The only evidence presented to show the automated enforcement system was working properly was the maintenance log prepared by an employee of a company that was in charge of maintaining and servicing the equipment used for photo enforcement. There was nothing in the record to support the conclusion that the officer described the mode of preparation of the maintenance logs in any respect or that the sources of information and method and time of preparation were such as to indicate trustworthiness. The judgment was reversed.

Com. v. Janda, 2011 PA Super 27, 14 A.3d 147 (2011)

Defendant appealed conviction of four counts of burglary, four counts of theft by unlawful taking, and nine counts of receiving stolen property. The trial court did not err by admitting printed photos, rather than a memory card, from two victims' digital camera. Printed photographs taken by witness's digital camera were not rendered inadmissible under best evidence rule based on camera's use of memory card, in burglary prosecution; Defendant did not assert that the printed photograph was, or even might have been, a misrepresentation of the image captured by the camera. However, further fact-finding was necessary to determine Defendant's prior record score. The judgment of sentence was vacated. The case was remanded for resentencing.

State v. Roseberry, 197 Ohio App. 3d 256, 2011-Ohio-5921, 2011

This case was an appeal of a conviction for breaking and entering and multiple other charges. Text messages between Defendant and the victim circumstantially proved that Defendant gained entrance into the house and subsequently removed the victim's missing property. In addition, the trial court did not abuse its discretion in allowing the victim to read her handwritten compilation of text messages or in receiving related exhibits into evidence. However, photos of text messages were improperly admitted and the error deprived Defendant of a fair trial on the breaking and entering and theft charges. For photographs, a witness with personal knowledge of the subject of the photographs may authenticate them by testifying that the photographs fairly and accurately depict the subject at the time they were taken. The judgment was affirmed in part as to the convictions for having weapons while under disability and receiving stolen property. The judgment was reversed in part, and remanded for a new trial as to the breaking and entering and theft charges.

People v. McCoy, 89 A.D.3d 1218, 933 N.Y.S.2d 425 (3d Dep't 2011)

This case was an appeal of conspiracy and murder charges. Photographic evidence was not challenged. Photos retrieved from a cell phone found next to the victim's body were properly admitted into evidence. While the person who took the photos—presumably the victim—was not available to authenticate the photos, evidence was presented as to how they were retrieved from the cell phone and how they could not have been altered after the phone was recovered by the police. When no witnesses are available who have viewed the subject matter portrayed, valid alternative grounds may exist for authenticating a photograph and admitting it into evidence, such as testimony, especially that by an expert, tending to establish that the photograph truly and accurately represents what was before the camera. The judgment was affirmed.

Crutcher v. State, 68 So.3d 724 (Miss. Ct. App. 2011)

After a jury trial, Defendant was convicted of selling cocaine. Defendant sought review, challenging the denial of his motion for a mistrial, the admission of a videotape into evidence, the chain of custody of the cocaine, and his sentence. Defendant argued that the State failed to lay a sufficient evidentiary foundation to enter a videotape of the drug sale into evidence. The court concluded that the videotape was properly authenticated by two police officers who testified that the videotape accurately depicted the transaction as it occurred. Prior to its admission into evidence, a document or photograph must be authenticated, and the same standards used in determining the admissibility of photographs are applicable to the admission of videotapes. The Court affirmed the judgment.

State v. LeBlanc, 76 So.3d 572 (La. Ct. App. 4th Cir. 2011)

Defendant appeal conviction of copper telephone cable valued in excess of $500. Photographs of truck containing cable wire in back were properly authenticated in theft prosecution; owner of truck and employee for the telephone company to whom cable purportedly belonged took the photographs, and testified that the photographs depicted exactly what they depicted. However, a rational trier of fact could have found that the cable had less than a value of $300, in effect at the time of Defendant's arrest. Judgment reversed and remanded.

Dillion v. Reid, 312 Ga. App. 34, 717 S.E.2d 584 (2011)

This case involved a landowner filing action against his neighbors regarding placement of their floating dock. Aerial photographs showing location of docks on lake were admissible in breach of contract action brought by lot owner against adjacent lot owner; although the photographs were taken by unmanned cameras and did not have time stamps, lot owner testified that he obtained them from online mapping websites, the photographs contained copyright dates, and lot owner testified that he was able to confirm the dates they were taken by his knowledge of the water level of lake depicted in photographs, and that he personally observed the docks during those times and the pictures accurately depicted their locations. The Court of appeals affirmed the judgment.

Alexis v. State, 313 Ga. App. 283, 721 S.E.2d 205 (2011)

Defendant appealed conviction on robbery and assault charges. The trial court did not err in admitting a digital photograph of Defendant brandishing a silver handgun that was found on a cell phone in the co-Defendants' car because the co-Defendants identified it as an accurate depiction of Defendant holding a handgun. The photograph was relevant to link Defendant to the crimes given Defendant's defense that he was not present during the robberies and that the co-Defendants only named him as a participant in the crimes to get a favorable plea bargain from the State. Party lays a proper foundation for the admission of a photograph by showing that it fairly and accurately represents the object, scene, or person depicted. Any witness familiar with the subject depicted can authenticate a photograph; the witness need not be the photographer nor have been present when the photograph was taken. The Court affirmed Defendant's convictions.

People v. Goldsmith, 193 Cal. App. 4th Supp. 1, 122 Cal Rptr.3d 110 (App. Dep't Super. Ct. 2011)

The case involved a traffic violation. In a bench trial, the court admitted photographic evidence obtained from an automated traffic enforcement system (ATES) and found Defendant guilty of failing to stop at a red signal light. Defendant appealed. The court of appeal held that the ATES evidence was properly admitted. Photographs taken by an ATES could be admissible even if the testifying officer was not a percipient witness to the violation and was not personally responsible for setting up the camera. Authentication of a photograph may be provided by the aid of expert testimony, even if there is no one qualified to authenticate the photograph from personal observation, and even if the person who took the photograph does not testify. In the current case, an officer provided expert testimony regarding the operation of the ATES and the photographs it produced, based on information from city traffic engineers and the ATES operator, as well as his experience with images obtained from the cameras. Finally, the data and images on the photographs did not constitute hearsay because they did not amount to a statement from a human declarant. A data bar affixed to the bottom of the photographs was not entered by a person but rather was generated by the ATES once the system's sensors were triggered. The Court affirmed the judgment.

People v. Coleman, 77 A.D.3d 591, 911 N.Y.S.2d 288 (1st Dep't 2010)

The case involves the conviction for sale of controlled substance. The court properly exercised its discretion in admitting photographs that generally depicted the scene of the crime and the surrounding area. The People were not required to lay a foundation, in prosecution for third-degree criminal sale of a controlled substance, for their introduction into evidence of photographs that generally depicted the scene of the crime and the surrounding area, where police testimony made it clear that the photos were not intended to represent the officer's viewpoint or his ability to observe the sale; photos could not have deprived Defendant of a fair trial.

Com. v. Rodriguez, 457 Mass. 461, 931 N.E.2d 20 (2010)

The case is about two Defendants, appealing separate convictions for murder in the first degree and for being an accessory before the fact to the murder. First Defendant's conviction was vacated because error was committed in the admission of autopsy photographs and the testimony of the medical examiner. The photographs were not properly authenticated because the medical examiner who testified did not personally conduct or observe the victim's autopsy. Photographs usually are authenticated directly through competent testimony that the scene they show is a fair and accurate representation of something the witness actually saw; alternatively, authenticity may be established circumstantially. However, despite the error, sufficient evidence was presented to support the elements of murder in the second degree; thus, the verdict was reduced against first Defendant. Because second Defendant was charged as an accessory before the fact but the Commonwealth only presented evidence that second Defendant aided others in committing the felony, second Defendant was improperly convicted; the evidence presented only indicated that second Defendant kicked the victim during the beating. The court vacated first Defendant's conviction for murder in the first degree and remanded to the trial court a guilty verdict against first Defendant for murder in the second degree. The court reversed second Defendant's conviction and set aside the verdict.

State v. Lanieux, 39 So.3d 606 (La. Ct. App. 5th Cir. 2010)

Defendant appealed a conviction of aggravated flight from an officer. Defendant argued that the trial court erred by denying his motion to exclude the State's cumulative and prejudicial photographs because the technician who took the photographs was not present to testify and that no other foundation was presented to show that the photographs depicted what the officer described. The appellate court disagreed. The proper foundation for the admission of a photograph into evidence is laid when a witness, in this case the officer, having personal knowledge of the subject

depicted by the photograph identifies it as such. Defendant also contended that the officer's testimony should have been sufficient to describe the circumstances of the chase and that the photographs had a prejudicial effect in that they did not accurately depict the conditions of the chase that occurred at night. The instant court found that even though the photographs were taken during the day and not at night when the pursuit occurred, they were relevant to show the route Defendant took and the area he covered as he fled from the officer. The instant court also found that defense counsel elicited during his cross-examination of the officer that the streets would have had artificial lighting as opposed to daylight when the incident occurred. The judgment was affirmed.

People v. Beckley, 185 Cal. App. 4th 509, 110 Cal. Rptr.3d 362

A jury convicted two Defendants of one count of first-degree murder and two counts of attempted premeditated murder. Defendants appealed. Photograph downloaded from social networking website was not properly authenticated for admission in murder trial as accurately depicting that defense witness had flashed gang sign shown in the photograph, where detective who downloaded the photograph could not testify from his personal knowledge that the photograph truthfully portrayed witness flashing the gang sign and no expert testified that the picture was not a composite or faked photograph. The appellate court modified the judgments as to each Defendant by striking the street gang enhancements for reasons contained in the unpublished portion of the opinion.

Johnson v. State, 2010 Ark. App. 153, 375 S.W.3d 12 (2010)

Defendant appealed her conviction for murder in the second degree, with a firearm enhancement. Sufficient foundation existed for admission of photographs of items from victim's car in Defendant's trial for second-degree murder; crime scene where car was located was in a remote location that was secured by police shortly after victim's 911 call was made, and officer who took photographs testified that he did not touch items before photographing them. Further, the admission of Defendant's statement was proper because the testimony established that the transcript at issue was a true and accurate transcription of Defendant's tape-recorded statement, except for an omitted portion. The jury was also instructed that the recording took precedence over the transcript. Alternatively, there was no prejudice in the admission of the transcript because the jury heard the entire statement and Defendant testified at length. The judgment was affirmed.

McMillan v. State, 139 So.3d 184 (Ala. Crim. App. 2010)

Defendant was convicted of capital murder for the intentional murder of one victim by shooting him in the course of a first-degree robbery, and for the intentional murder of the second victim by shooting him inside a vehicle. State presented sufficient foundation, in this capital murder trial, for admission of photographs from disposable camera found in murder victim's truck; two witnesses authenticated that photographs showed Defendant as he appeared at time of offense, and other witness asserted that gun photographs depicted automatic weapon. On appeal there was no plain error resulting from the admission into evidence of a wedding photograph and the identification by his widow of the victim in the photograph. It generally is agreed that the photograph of the victim of the homicide, taken before the alleged murder, is admissible for the purpose of identification. This is usually admitted in connection with the testimony of a witness who saw the alleged deceased at the time of the killing and who is called upon to identify the deceased as the person in the photograph. The judgment was affirmed.

US v. Patillo, 403 Fed. Appx. 761 (3d Cir. 2010)

Found guilty on four charges stemming from his involvement in a conspiracy to deal crack cocaine, Defendant appealed from the US District Court for the District of New Jersey, arguing among other things, improperly admitted evidence. The photograph was properly authenticated through a police officer's testimony that she used the photograph to identify Defendant after she bought drugs from him while working undercover, and nothing suggested it did not exist when used to identify Defendant, thus a Brady claim, that the date of the photograph was withheld, failed. The motion to withdraw was granted and the judgment of the District Court was affirmed.

State v. Swinton, 847 A.2d 921 (Conn. 2004)

- Followed by State v. Place, 153 Conn. App. 165, 100 A.3d 941, 2014 Conn. App. LEXIS 406 (2014)

This case was about a robbery in which the victim did not mention the visible tattoos on the Defendant when describing him. Defendant's failed to present any evidence that the tattoos had not been altered in the two and one-half years

since the robbery, and therefore failed to meet the foundational requirements necessary for admitting such evidence. The Defendant claimed he was deprived of his due process right to fair trial as a result of the trial court's ruling that required him to subject himself to cross-examination if he chose to display his tattoos to the jury. However, although he claimed that a proper foundation was laid for him for to make a display of his tattoos to the jury because photographs the state entered into evidence depicted his tattoos the day after the robbery, he was required to show that it was reasonably probable that the substance of his tattoos had not been changed in important respects, which he failed to do, as he did not present evidence from any source that the tattoos on his body looked substantially the same as they did on the night of the robbery that occurred two and one-half years earlier. Also, the Defendant could not prevail on his claim that the trial court erred when it failed to admit into evidence a photographic array from which the bank teller was unable to identify a particular person as the robber, because the record contained overwhelming evidence that it was the Defendant who had robbed the bank.

- Followed by State v. Melendez, 291 Conn. 693, 970 A.2d 64, 2009 Conn. LEXIS 116

Defendant appealed conviction for sale of narcotics by a person who is not drug dependent and sale of narcotics within 1500′ of a licensed child day care center.

On appeal, Defendant claimed a due process violation for, among other things, allowing the introduction of a digital video disc (DVD) into evidence without a proper foundation.

The DVD was not new evidence; it depicted the same transactions as the original videotape that defense counsel had seen, albeit in an enhanced format. Parts of the DVD that exactly duplicated the original, unmodified videotape, played in real time, were not computer-generated evidence under *Swinton*. It was noted that the entire thrust of the Defendant's claim, both at trial and on appeal, pertained to the inadmissibility of the *modified* portions of the DVD. Thus, the Defendant did not appear to contend that the foundational requirements of *Swinton* apply to the footage that merely was taken from the 8 mm videotape, transferred to the DVD and never modified in any way. Moreover, to the extent that language in the Defendant's brief to this court arguably might be deemed to encompass such a claim, the Defendant failed to explain *why* such a foundation was necessary when the process involved had been demonstrated to result in nothing more than an exact copy of the original recording. Judgment affirmed.

Bryant v. State of Florida, 810 So.2d 532 (Fla. App. 1 Dist. 2002)

- Followed by Smith v. Geico Cas. Co., 127 So.3d 808, 2013 Fla. App. LEXIS 18895, 38 Fla. L. Weekly D 2477 (Fla. Dist. Ct. App. 2d Dist. 2013)

The time-lapse videos from the bus were properly admitted in an uninsured motorist case against an insurer since the insured stipulated that the videos were from the bus on the day of the accident; the finding that the videos were a fair and accurate representation of what occurred on the bus was proper. On appeal, it was argued that the videos were not fair and accurate representations of what occurred on the bus and that the probative value of the videos was outweighed by the possibility that they would mislead the jury because they did not "catch the entire motion of the insured. It catches him at certain points. We do not know what happened in the other frames." It was argued that the insurer's experts were able to mislead the jury by suggesting that the insured did not hit the seat in front of him during the accident as he had testified. The insured asserted that the videos were not a fair and accurate representation of what happened in the bus during the incident. However, the insured stipulated that the videos were from the bus on the day in question. As such, the Court could not say that the trial court abused its discretion in determining that the videos were a fair and accurate representation of what occurred on the bus that day.

- Followed by Hollis v. Sec'y, Dep't of Corr., 2014 U.S. Dist. LEXIS 13033 (M.D. Fla. Feb. 3 2014)

It was asserted that the trial court erred by admitting ATM photographs on the basis that a witness was not qualified to testify about the photographs.

Erroneously admitted evidence deprives a Defendant of fundamental fairness only if it was a crucial, critical, highly significant factor in the [Defendant's] conviction. The admission of the photographs was not a highly significant factor in Petitioner's conviction given that the individual in the photographs could not be identified and there was substantial evidence against Petitioner. Thus, any error in the admission of the photographs was harmless.

Rodd v. Raritan Radiologic Associates, P.A. et al., 860 A.2d 1003 (2004)

- Followed by State ex rel. D.H., 2010 N.J. Super. Unpub LEXIS 1073 (App. Div. May 20 2010)

This case involved a dispute over fingerprint cards, enlargements of which were admitted into evidence. The detective received two 10-print cards, one from AFIS, and one from the municipal police which, testimony indicates, bore the juvenile Defendant's name. Those cards were never received in evidence, however. And, even if they had been proffered, they would suffer from the same evidential deficiency as the enlargements did; the detective lacked the knowledge to testify that the cards in fact contained Defendant's prints for he had no knowledge of their preparation or recordation. The Court was satisfied that these records were improperly admitted into evidence, and since they were the only link between Defendant and the theft, his adjudication must be reversed. This made it unnecessary to address his remaining contentions. The order adjudicating Defendant a delinquent was reversed.

RELEVANT AND MATERIAL

State v. Williams, 299 Kan. 509, 324 P.3d 1078 (2014)

Defendant appealed conviction for premeditated first-degree murder; conspiracy to commit first-degree murder; and criminal possession of a firearm. Included in multiple arguments was whether the trial court erred in admitting a demonstrative photograph. Generally, in determining whether demonstrative photographs should be admitted, a trial court must determine whether they are relevant and whether a proper foundation has been laid. A proper foundation exists when the witness demonstrates he or she possesses the requisite skill and experience to conduct the demonstration and displays the accuracy and reliability of the models and photographs. With regard to a photograph of a reconstructed scene, the proper test is whether the conditions are the same or substantially similar to the events depicted. Minor differences go to the weight of the evidence rather than its admissibility. The question of what constitutes a permissible variation depends on whether it tends to confuse or mislead the jury. A trial court has broad discretion when making these determinations, and the court's decision to admit such photographs must be accepted on appellate review absent a showing of abuse of discretion. Photographic evidence of reconstructed events is admissible as long as a proper foundation is laid and any discrepancies between the reconstruction and the original event are explained. Judgment affirmed.

Knapp v. State, 9 N.E.3d 1274 (Ind. 2014)

Defendant appealed his sentence for murder, challenging his probation status. Photographic evidence was not challenged. For purposes of establishing a foundation necessary for admission of crime scene photographs, medical examiner was not required to testify that the photographs were a true and accurate representation of victim's body, in murder prosecution, as photographs were used for substantive rather than demonstrative purposes, as "silent witnesses" of mature maggot activity on victim's body at the time she was found, which none of the on-scene witnesses addressed, but was the basis for medical examiner's opinion of victim's time of death. Judgment affirmed.

People v. Woodworth, 11 A.D.3d 1368, 976 N.Y.S.2d 631 (4th Dep't 2013)

Defendant appealed a conviction for sexual abuse in the first-degree and multiple other charges.

Defendant argued that the court improperly admitted in evidence photographs that had been enhanced by the People. At trial, the People laid a proper foundation by authenticating the photographs. Additionally, the photographs were relevant with respect to the nature and extent of the victim's injuries, and their sole purpose was not "to arouse the emotions of the jury and to prejudice…Defendant." Photographs that had been enhanced by prosecutor were properly admitted into evidence in prosecution for sexual abuse and other related charges, where prosecutor laid a proper foundation by authenticating the photographs, photographs were relevant with respect to the nature and extent of the victim's injuries, and their sole purpose was not to arouse the emotions of the jury and to prejudice Defendant. Judgment was affirmed.

Lambert v. Coonrod, 359 Ill. Dec. 262, 966 N.E.2d 583 (App. Ct. 4th Dist. 2012)

Plaintiffs, claimant and spouse, filed a two-count complaint against Defendant property owner to recover damages for injuries sustained by the claimant at the owner's residence. A jury found in favor of the owner and against plaintiffs. The plaintiffs appealed. There was no error in admitting the photographs into evidence. The photos were relevant. The pictures showed the interior of the shed where the accident took place, as well as the white-painted spool that the claimant stepped on before falling. In general, photographs are admissible into evidence if they are identified by a witness who has personal knowledge of the subject matter depicted in the photographs and the witness testifies that the photographs are a fair and accurate representation of the subject matter at the relevant time. The judgment was affirmed.

Commonwealth of Pennsylvania v. Duca, 165 A. 825 (1933)

- Followed by Commonwealth v. Tejada, 2015 PA Super 2, 107 A.3d 788, 2015 Pa. Super. LEXIS 2 (Pa. Super. Ct. 2015)

This case was about a robbery in which the accused was identified by means of an arrest photo. Defendant asserted that the trial court erred by permitting a witness to identify Defendant as the perpetrator of the victim's robbery using his arrest photograph. Defendant advanced two arguments in support of this claim: (1) the photograph was the fruit of the unlawful show-up identification that occurred on the night of the robbery (unproven) and (2) using the photograph to identify Defendant in court itself was improper. The trial court found that his arrest photo was relevant and admissible, as he had changed his appearance prior to trial, which is why the witness could not identify him in court.

Welch v. State, 992 So.2d 206 (2008 Fla.)

- Followed by Puglisi v. State, 56 So.3d 787, 2010 Fla. App. LEXIS 19465, 36 Fla. L. Weekly D 7 (Fla. Dist. Ct. App. 4th Dist. 2010)

This was a murder case in which Defendant and his new boyfriend went to the victim's house where the victim had sex with the boyfriend. Defendant walked in on them and the boyfriend proceeded to beat and stab the victim. The pictures submitted were intended to show premeditation. After conviction, Defendant appealed, asking the court to reverse and remand for a new trial because the trial court abused its discretion in admitting photographs which it alleged had little probative value and were intended to inflame the jury. Relevancy, not necessity, is the test for admissibility of photographs into evidence. Even if the photographs were relevant, the trial court must determine whether the portrayal is so gruesome and inflammatory that it creates an undue prejudice in the minds of the jurors. The photographs at issue depicted blood spatter in two different rooms—the master bedroom and bathroom—indicating the murder occurred in two different rooms. Thus, the pictures were relevant to show premeditation. For the foregoing reasons, the Court affirmed the judgment and sentence.

MORE PROBATIVE THAN PREJUDICIAL

State v. Brown, 88 A.3d 1101 (R.I. 2014)

Defendant appealed conviction for murder. Defendant maintains that the trial justice erred when he denied Defendant's motion to exclude three autopsy photographs from evidence. The Defendant objected to three of the eight photographs from the autopsy that the state wished both to introduce as evidence and to display in the courtroom. The Defendant argued that because the cause of death was not in dispute, whatever limited probative value the photos would provide was outweighed by their prejudicial effect. Defendant argued that photographs depicted the victim's remains in the aftermath of the autopsy, and not just the physical damage that Defendant was alleged to have inflicted. The trial justice overruled the objection and found the photos were not overly prejudicial. He reasoned that this Court's precedents favor admission of photographs, even if they are unpleasant and that the photos were probative and relevant because they assisted the medical examiner in explaining his testimony. Judgment affirmed.

People v. Woodworth, 11 A.D.3d 1368, 976 N.Y.S.2d 631 (4th Dep't 2013)

Defendant appealed a conviction for sexual abuse in the first-degree and multiple other charges.

Defendant argued that the court improperly admitted in evidence photographs that had been enhanced by the People. At trial, the People laid a proper foundation by authenticating the photographs. Additionally, the photographs were relevant with respect to the nature and extent of the victim's injuries, and their sole purpose was not "to arouse the emotions of the jury and to prejudice…Defendant." Photographs that had been enhanced by prosecutor were properly admitted into evidence in prosecution for sexual abuse and other related charges, where prosecutor laid a proper foundation by authenticating the photographs, photographs were relevant with respect to the nature and extent of the victim's injuries, and their sole purpose was not to arouse the emotions of the jury and to prejudice Defendant. Judgment was affirmed.

People v. Ellis, 154 Cal. Rptr.3d 378 (Cal. App. 1st Dist. 2013)

Defendant appealed conviction for committing lewd acts upon a child under the age of 14. Defendant argued that photographs taken during the victim's sexual assault examination were admitted in evidence in violation of his Sixth Amendment right to confrontation. The court concluded that the photographs were not testimonial hearsay and were properly admitted. The photographs were themselves probative demonstrative evidence of a physical trauma suffered by the victim. The photographs were not out-of-court hearsay "statements" by a "person" that would implicate a Sixth Amendment confrontation right. Judgment was affirmed.

Rolle v. State, 367 S.W.3d 746 (Tex. App. Houston Dist. 2012)

A jury convicted Defendant of capital murder, based on an allegation that he caused the victim's death during the course of committing or attempting to commit a burglary of a habitation. Defendant appealed. Defendant argued that the trial court erred by admitting an autopsy photograph of the victim's unborn fetus into evidence during the trial's guilt-innocence phase. The court of appeals agreed that it was error to admit the photograph. There was little probative value in relation to the offense, as to which the death of the fetus was not an element, and other evidence was admitted of the pregnancy and the fetus's death. However, the error was harmless because the State did not dwell on or emphasize the single color photograph depicting an intact fetus; there was other, unobjected-to evidence of the fetus's death; and, although there was no eyewitness testimony that Defendant fired the shots, the photograph did not affect the determination of Defendant's guilt. The court affirmed the trial court's judgment.

People v. Marra, 96 A.D.3d 1623, 946 N.Y.S.2d 783 (4th Dep't 2012)

Defendant appealed a judgment that convicted him of first-degree rape. Prosecutor laid proper foundation for admission of hospital photographs of victim in Defendant's rape prosecution, where nurse who took them testified that photographs accurately represented portions of victim's body depicted therein. The photographs were relevant and their probative value outweighed their potential for prejudice. However, in light of Defendant's age, his lack of a prior criminal record, and other mitigating circumstances, the sentence of a determinate term of incarceration of 18 years followed by 15 years of postrelease supervision was unduly harsh and severe. The judgment was unanimously modified by reducing the sentence; and as so modified, the judgment was affirmed.

United States v. Gray, 699 F.3d 556 (5th Cir. 2012)

Defendant appealed conviction for possession of crack cocaine with intent to distribute. Photographs of Defendant, the driver of vehicle who was arrested on outstanding warrants, posing with gun were properly authenticated; police detective testified that photographs were downloaded from passenger's cell phone with her authorization and that they appeared to be "(Defendant) holding a handgun or revolver," and government was not seeking to prove anything relating to time pictures were taken. Admission of photographs of Defendant posing with a gun was unfairly prejudicial because there was no probative value, but the error was harmless because substantial evidence supported Defendant's conviction. The district court's judgment was affirmed.

Jones v. U.S., 27 A.3d 1130 (D.C. 2011)

This case was an appeal of first-degree murder conviction, along with escape and weapons charges. There was no abuse of discretion in the trial court's balancing of the probative value of the evidence against the danger of unfair prejudice. Test of admissibility is whether the photograph accurately represents the facts allegedly portrayed by it. The Court affirmed the judgment.

State v. William M., 225 W.Va 256, 692 S.E.2d 299 (2010)

The case involved a conviction on sexual abuse by a parent, guardian, or custodian and on sexual abuse in the third degree. Defendant appealed, arguing that 98 colposcopic images were new and material evidence and that his motion for a new trial had been improperly denied. A doctor performed a sexual assault evaluation on Defendant's daughter, examining her using a colposcope, a medical instrument that magnified the genitals and could be used to take pictures during a genital exam. Digital photographs may be authenticated in the same manner as a film photograph, by a witness with personal knowledge of the scene depicted who can testify that the photograph fairly and accurately represents it. The doctor could have testified had the images been admitted in the original trial. However, the 98 colposcopic images were not provided in discovery or brought to court. In view of the State's heavy reliance on the uncontradicted medical testimony, the disclosure of the previously unsubmitted images could produce an opposite result at a second trial and would have value as both exculpatory and impeachment evidence. Reversing, the Court agreed that the circuit court erred when it denied Defendant's motion for a new trial based on the newly discovered images. The Court reversed the conviction and remanded the case for a new trial on all charges.

Harris v. State, 843 So.2d 856 (Fla. 2003)

- Followed by Victorino v. State, 127 So.3d 478, 2013 Fla. LEXIS 2198, 38 Fla. L. Weekly S 707 (Fla. 2013)

This case involved a murder and the killing of a dog. Defendant asserted that trial counsel should have objected to several photographs because they created a risk of unfair prejudice that substantially outweighed their probative value. However, the assertion did not specify which photographs he challenged and did not attach any photographs to his

petition. Accordingly, Defendant did not sufficiently plead this claim. Defendant also contended that trial counsel should have objected to three photographs depicting a dachshund lying on the floor in the corner of a bedroom. While there was testimony in the record that Defendant stated that he killed the dog, the photographs were uniquely probative of the State's allegations that the dog was killed in a cruel, painful manner. Because the probative value of the photographs was so high, any danger of unfair prejudice did not substantially outweigh the probative value.

Hayes v. State, 85 S.W.3d 809 (Tex. Crim. App. 2002)

- Followed by Sifuentes v. State, 2013 Tex. App. LEXIS 8105 (Tex. App. San Antonio July 3 2013)

At issue was the admittance into evidence photographs of the victim taken in the hospital. They were visual representations of the officers' testimony regarding her condition, and the mere fact that the photographs depicted the victim's badly bruised body did not automatically render them more prejudicial than probative. They refuted Defendant's claims that she never noticed anything wrong with the victim or that the bruising might have been caused by the efforts to resuscitate the victim. The trial court did not abuse its discretion by admitting into evidence autopsy photographs because they depicted what several witnesses described regarding the victim's injuries, they were not notably duplicate or cumulative as they showed injuries to different areas of the body, they aided the physician's explanation of the victim's injuries, and they were relevant to the State's claim that Defendant committed the offense of injury to a child by omission and negated her defenses. Accordingly, the Court held that the trial court did not err in concluding the probative value of the photos was not substantially outweighed by any prejudicial effect.

- Followed by Garcia v. State, 2011 Tex. App. LEXIS 2848 (Tex. App. Corpus Christi Apr 14 2011)

Appellant was indicted for aggravated robbery but found guilty of the lesser-included offense of aggravated assault. A photograph of a deceased person's hand, which was wearing a glove, had probative value because it established that the assailants took precautions to avoid leaving fingerprints. The photograph also had probative value as to appellant's liability as a party, plus no other photographs of the deceased person were admitted. The photograph was relevant and its probative value outweighed any possible prejudicial effect. The Court affirmed on appeal.

- Followed by Garcia v. State, 2010 Tex. App. LEXIS 8313 (Tex. App. Austin Oct 12 2010)

Defendant was convicted for shooting the two victims, cab drivers, to death. All of the admitted autopsy photographs show the bullet wounds to the heads of the two victims, but it was argued that three photographs also showed the surgical mutilation caused by the autopsy process. It is this mutilation that makes these three photographs more disturbing than the other autopsy photographs. Nothing of significance to the State's case was added by also showing the gunshot wounds from the inside of Hinojosa's skull and after Parrish's scalp had been reflected. Under the circumstances, it was concluded that the probative value of these three photographs was outweighed by the danger of unfair prejudice, and that the trial court abused its discretion by admitting these photographs in evidence. Even though the trial court erred by admitting three autopsy photographs that showed the surgical mutilation caused by the autopsy, the error was harmless and the conviction upheld because the Court held that the evidence was sufficient to support Defendant's conviction.

Spann v. State, 771 So.2d 883 (2000)

- Followed by Conners v. State, 92 So.3d 676, 2012 Miss. LEXIS 339 (Miss. 2012)

A jury convicted Defendant of two counts of murder and two counts of possession of a firearm by a felon. Defendant appealed for, among other things, that he was prejudiced by deficient performance by counsel for not objecting to admission of some of 36 photographs admitted. There was little likelihood that the admission of several additional photographs of the victims so inflamed the jury against Defendant as to create a probability that the outcome of his trial would have been different. Conviction was upheld.

- Followed by Gebben v. State, 108 So.3d 956, 2012 Miss. App. LEXIS 332 (Miss. Ct. App. 2012)

Defendant drove around a stopped school bus and ran over and killed a young child; he was convicted of culpable-negligence manslaughter and fleeing the scene of an accident. Defendant claimed admission of the photographs of the victim was error because "[i]t was undisputed by both sides that the manner of death was Gebben's vehicle." Because the photographs were neither cumulative nor unfairly prejudicial, the Court found the circuit court remained within its discretion in admitting the photographs.

State v. Ervin, 105 Conn. App. 34*+; 936 A.2d 290*+; (2007 Conn. App)

- Followed by State v. Myers, 126 Conn. App. 239, 11 A.3d 1100, 2011 Conn. App. LEXIS 29 (2011)

A jury convicted Defendant of manslaughter with a firearm, carrying a pistol without a permit, tampering with physical evidence, and criminal possession of a firearm. The Superior Court in the judicial district of New Haven (Connecticut) sentenced him to 50 years. On appeal, the Defendant contended that a five by seven photograph of him likely inflamed the emotions of the jury in a death-related case. Here, the court did not abuse its discretion in finding that this unremarkable photograph of the Defendant was not inflammatory and was relevant to identifying him. Nor, for the same reasons, did the court abuse its discretion in admitting the photograph as a full exhibit and permitting the state to display briefly an enlarged version of the exhibit during closing argument. Accordingly, the claim failed.

Welch v. State, 992 So.2d 206 (2008 Fla.)

- Followed by Puglisi v. State, 56 So.3d 787, 2010 Fla. App. LEXIS 19465, 36 Fla. L. Weekly D 7 (Fla. Dist. Ct. App. 4th Dist. 2010)

This was a murder case in which Defendant and his new boyfriend went to the victim's house where the victim had sex with the boyfriend. Defendant walked in on them and the boyfriend proceeded to beat and stab the victim. The pictures submitted were intended to show premeditation. After conviction, Defendant appealed, asking the court to reverse and remand for a new trial because the trial court abused its discretion in admitting photographs which it alleged had little probative value and were intended to inflame the jury. Relevancy, not necessity, is the test for admissibility of photographs into evidence. Even if the photographs were relevant, the trial court must determine whether the portrayal is so gruesome and inflammatory that it creates an undue prejudice in the minds of the jurors. The photographs at issue depicted blood spatter in two different rooms—the master bedroom and bathroom—indicating the murder occurred in two different rooms. Thus, the pictures were relevant to show premeditation. For the foregoing reasons, the Court affirmed the judgment and sentence.

State v. Bowman, 289 Conn. 809 (2008)

- Overruled in part by State v. Elson, 311 Conn. 726, 91 A.3d 862, 2014

In this murder case, the Defendant claimed that the trial court improperly admitted into evidence eight "exceptionally gruesome" photographs of the deceased victim. Defendant argued that because neither the injuries nor the cause of death were disputed, the admission of the photographs violated his right to a fair trial. The Supreme Court concluded that Defendant's unpreserved evidentiary claim was not reviewable, and that pain error review was precluded because the admission of the photographs did not result in any manifest injustice to Defendant. The photographs were used by the State to explain the layout of the crime scene and explore the extent of the victim's injuries.

Brooks v. State, 973 So.2d 380 (2007 Ala. Crim. App.)

- Followed by Carroll v. State, 2015 Ala. Crim. App. LEXIS 65 (Ala. Crim. App. Aug 14 2015)

Carroll argues that the circuit court abused its discretion by allowing the State to admit 17 photographs taken during autopsy. According to Carroll, the State presented sufficient evidence to establish "Carroll's involvement in Mr. Turner's death"; therefore, the admission of the autopsy photographs "serve[d] no purpose as the issue was undisputed." Carroll asserts that the admission of the autopsy photographs "only served to unnecessarily arouse the passion and sympathy of the jury"; therefore, his conviction and sentence must be reversed. The Court thoroughly reviewed all the photographs relating to the Turner's murder that were admitted into evidence. The photographs were relevant and admissible to corroborate Dr. Ward's testimony establishing the extent of Turner's wounds and the cause of his death. The photographs are not unduly gruesome, and the Court concluded that their prejudicial effect did not outweigh their probative value. Therefore, the Court held that no error resulted from the admission of the autopsy photographs.

- Followed by Kelley v. State, 2014 Ala. Crim. App. LEXIS 62 (Ala. Crim. App. Sept 5, 2014)

In Defendant's death penalty case, objections to admission of photographs were overruled. On appeal, Defendant argued that the circuit court abused its discretion by allowing the State to admit autopsy photographs that showed that an animal and insects had altered the body after death. It was argued that the photographs and testimony regarding postmortem animal and insect activity were unduly gruesome, irrelevant, and prejudicial. The Court deemed the

photographs relevant and admissible to establish the injuries Defendant inflicted on the victim. The photographs and testimony relating to postmortem animal and insect activity were also relevant and admissible to distinguish between the injuries Defendant caused and the injuries that he did not. Further, although the photographs and the testimony were certainly unpleasant, they were not unduly gruesome or unfairly prejudicial. Consequently, the Court concluded that their prejudicial effect did not outweigh their probative value. As such, no error resulted from the admission of the photographs and testimony relating to postmortem animal and insect activity.

- Followed by White v. State, 2013 Ala. Crim. App. LEXIS 71 (Ala. Crim. App. Aug 30 2013)

This case was about the rape and murder of a woman, Parker. White argued that the circuit court erroneously allowed the State to introduce gruesome, irrelevant, and prejudicial photographs. Specifically, White argued that the circuit court erroneously allowed the State to introduce photographs depicting the body of another female murder victim, Black, as it was found. According to White, the photographs of Black's body were unnecessary to the State's case because they were cumulative to a crime-scene technician's testimony. He further argued that the photographs were unduly prejudicial. Thus, White argued his conviction must be reversed. Evidence establishing that White raped and murdered Black was admissible to establish his identity as the individual who also raped and murdered Parker. The photographs were relevant and admissible to corroborate testimony establishing that Black and Parker had similar body types, were roughly similar in age, and were murdered in a similar manner. Although they are certainly unpleasant, the photographs are not unduly gruesome, and the Court concluded that their prejudicial effect did not outweigh their probative value. Therefore, the Court held that no error resulted from the admission of the photographs.

- Followed by McCray v. State, 88 So.3d 1, 2010 Ala. Crim. App. LEXIS 136 (Ala. Crim. App. 2010)

In this murder case, Defendant first argued that the trial court erred in admitting into evidence a videotape of the crime scene, numerous photographs of the crime scene, and several autopsy photographs of the wounds on the victim's body taken just before the autopsy was performed. He argued that the videotape and photographs were gruesome, were largely duplicative, and were offered solely to inflame the jury and that their prejudicial effect outweighed any probative value. The Court deemed the photographs and the videotape relevant and admissible to show the scene of the crime and the extent of the wounds to the body. Although certainly unpleasant, they were not unduly gruesome, and the Court concluded that their prejudicial effect did not outweigh their probative value. Therefore, the Court found no error, much less plain error, in the admission of the photographs and videotape.

- Followed by Mitchell v. State, 84 So.3d 968, 2010 Ala. Crim. App. LEXIS 78

Defendant and another took the lives of three people during the course of a robbery. Defendant was also convicted of an additional count of capital murder because two or more people were murdered pursuant to one course of conduct. Argument was made that the circuit court erred in admitting gruesome photographs of the victims' wounds. The Court held that they were relevant and admissible to show the extent of the victims' injuries. Further, although unpleasant, the photographs were not unduly gruesome. Therefore, the circuit court did not commit any error in allowing the photographs to be admitted at trial.

England v. State, 940 So.2d 389, 2006 Fl

- Followed by McWatters v. State, 36 So.3d 613, 2010 Fla. LEXIS 406, 35 Fla. L. Weekly S 169 (Fla. 2010)

This case was about two murders in which the first victim's homicide was substantially similar to other homicides. In the guilt-phase claims, Defendant challenged several of the trial court's rulings concerning the admissibility of evidence. First, it was argued that the trial court erred in admitting four autopsy photographs because the photographs were irrelevant to any material fact in issue, and even if they were relevant, the relevance was substantially outweighed by unfair prejudice. The Court held that the photographs were relevant to establish the manner and cause of death and the HAC aggravator. Likewise in the instant case, the autopsy photographs were relevant and corroborative of the doctor's testimony. During a proffer, the doctor stated that he relied on these four photographs to determine the manner and cause of death, and he used the photographs during his testimony to explain to the jury the condition of the bodies and the manner and cause of death. The photographs were also relevant to establishing HAC because the doctor used these photographs to demonstrate how the victims were strangled. Thus, the Defendant's claim that the probative value of the photographs was substantially outweighed by unfair prejudice was without merit.

State v. Pettigrew, 860 P.2d 777 (N.M. App. 1993)

- Followed by State v. Ayers, 2013 N.M. App. Unpub LEXIS 188 (N.M. Ct. App. June 27 2013)

Defendant appealed from his conviction for second-degree murder arguing that the district court erred in numerous ways including allowing the State to show multiple photographs of the victim at trial because the photographs were more prejudicial than probative. Graphic photographs of the injuries suffered by deceased victims of crime are by their nature significantly prejudicial, but that fact alone does not establish that they are impermissibly so. Photographs are often more accurate than any description by words and give a clearer comprehension of the physical facts than can be obtained from the testimony of witnesses. The Defendant's motion to amend the docketing statement and affirm his conviction was denied.

ENLARGEMENTS

Arlton v. Schraut, 936 N.E.2d 831 (Ind. Ct. App. 2010)

Plaintiff patient sued Defendants for medical malpractice. Jury verdict was returned in favor of care providers. Patient appealed. Patient argued that the trial court erred in refusing to admit enlarged copies of angiogram photos. Patient established adequate foundation for admission of enlarged copies of angiogram photographs; copies were merely enlarged version of much smaller angiogram images already in evidence, there was no showing that enlarged photographs had been altered in any other way, and expert witness testified that enlargements accurately represented the digital images already admitted. Patient also argued that the trial court erred in refusing to instruct the jury that they could review digital images that had been admitted into evidence by instructing the bailiff, whereupon they could view the images in the courtroom. The court of appeals agreed. The tendered instruction was supported by the evidence. The images already been admitted and they were key evidence in proving or disproving the claim of negligence. The jury was never informed that they could have access to the digital images if they so desired. The judgment was reversed.

Cited in Corsi v. Town of Bedford, 58 A.D.3d 225, 868 N.Y.S.2d 258, 2008 N.Y. App. Div. LEXIS 9010

Plaintiff owners brought an action against Defendant town, seeking to establish title, by adverse possession, to real property belonging to the town which adjoined the owners' property. Judgment was in favor of the town. Plaintiffs appealed. The town's defense centered on aerial photos of the property, purportedly taken in 1995 and 1996, and testimony that those photos showed that none of the improvements alleged by the owners had been made by that time. The appellate court found that the 1995 photo and enlargements were properly admitted and authenticated. The Plaintiffs' objections to the enlargements of the 1995 aerial photograph were properly rejected by the Court, without the need for testimony as to the process by which the enlargements were generated, on the basis of the testimony that the enlargements were identical to the original except for scale. The admission of the 1996 aerial photograph and its enlargements was improper; however, the 1995 aerial photograph and enlargements provide a sufficient evidentiary basis for the Supreme Court's determination. Judgment affirmed.

State v. Ervin, 105 Conn. App. 34*+; 936 A.2d 290*+; (2007 Conn. App)

- Followed by State v. Myers, 126 Conn. App. 239, 11 A.3d 1100, 2011 Conn. App. LEXIS 29 (2011)

A jury convicted Defendant of manslaughter with a firearm, carrying a pistol without a permit, tampering with physical evidence, and criminal possession of a firearm. The Superior Court in the judicial district of New Haven (Connecticut) sentenced him to 50 years. On appeal, the Defendant contended that a five by seven photograph of him likely inflamed the emotions of the jury in a death related case. Here, the court did not abuse its discretion in finding that this unremarkable photograph of the Defendant was not inflammatory and was relevant to identifying him. Nor, for the same reasons, did the court abuse its discretion in admitting the photograph as a full exhibit and permitting the state to display briefly an enlarged version of the exhibit during closing argument. Accordingly, the claim failed.

EQUIPMENT

Dampier v. State, 973 So.2d 221 (2008)

- Followed by Sanders v. State, 63 So.3d 554, 2010 Miss. App. LEXIS 130 (Miss. Ct. App. 2010)

This case was about a gruesome murder in which the Defendant objected to the admission of three photographs that were taken during the autopsy and use of an overhead projector to display the photographs. After argument from both

sides, the circuit court overruled the objection because the probative value outweighed any possible prejudicial effect. Although the photographs in question were gruesome, as the circuit court pointed out, photographs depicting the body of a murder victim could hardly be described as anything but gruesome. As to the use of an overhead projector, it was utilitarian and sufficient in its allowing the jury to see all of the photographs at one time. Therefore, the objection to the use of the overhead projector was likewise overruled. Neither the admission of the photographs nor the use of a projector to show them were an abuse of discretion by the circuit court; the issue was found to be without merit.

VIDEOTAPES

People v. Chism, 58 Cal. 4th 1266, 171 Cal. Rptr.3d 347, 324 P.3d 183 (2014)

Defendant appealed first-degree murder, attempted robbery, and second-degree robbery convictions. Still photographs of murder suspects printed from security camera videotape using videocassette recorder were adequately authenticated by police officer's testimony that the videotape from which the photographs were printed accurately depicted her conduct and that of other people in the store immediately after the shooting, and by a police officer who watched the photographs being printed, even though the top and bottom portions of the photographs showed parts of the image that had not been visible in photographs printed earlier using different equipment. The trial court was directed to modify the abstract of judgment to reflect that Defendant was entitled to 96 days of conduct credit. In all other respects, including the verdict of death, the judgment was affirmed.

Crutcher v. State, 68 So.3d 724 (Miss. Ct. App. 2011)

After a jury trial, Defendant was convicted of selling cocaine. Defendant sought review, challenging the denial of his motion for a mistrial, the admission of a videotape into evidence, the chain of custody of the cocaine, and his sentence. Defendant argued that the State failed to lay a sufficient evidentiary foundation to enter a videotape of the drug sale into evidence. The court concluded that the videotape was properly authenticated by two police officers who testified that the videotape accurately depicted the transaction as it occurred. Prior to its admission into evidence, a document or photograph must be authenticated, and the same standards used in determining the admissibility of photographs are applicable to the admission of videotapes. The Court affirmed the judgment.

Fisher v. State, 7 Ark. App. 1 (1982)

- Followed by State v. Pickens, 141 Ohio St.3d 462, 2014-Ohio-5445, 2014 Ohio LEXIS 3108, 25 N.E.3d 1023 (2014)

Defense argued that the spliced videos submitted into evidence were not authenticated, but he provided no further argument or case authority for these claims. Defendant did not explain his objection to the authenticity of the video, which spliced together surveillance videos showing the time and progression of Defendant's movements. Counsel complained at trial that the state had never disclosed that the video was a spliced version of events. The trial court replied, "I don't know how you cannot know that that was spliced from other recordings that were made because it shows—it takes him outside the building." But Defendant raised no objections on appeal about the state's failure to notify the defense that the videotape was spliced. Thus, the Court rejected this claim.

People v. Rodriguez, 264 A.D.2d 690, 691, 698 N.Y.S.2d 1 (1999)

- Annotated Statutes—NY CLS CPL @60.10

Bank surveillance videotapes, and photographs made from those tapes, were properly admitted in evidence without expert testimony about the digitizing process used at FBI laboratory to slow tapes down and make still photos from them. Bank employee responsible for making original tapes testified that he compared original and slowed-down tapes, and that what was represented therein was identical except for speed.

Rogers v. State, 902 N.E.2d 871

- Followed by Canenepeel v. State, 2009 Ind. App. Unpub LEXIS 1554

This robbery case involved the admittance into evidence of a store's surveillance video footage and the allowing of the loss prevention supervisor to testify about the footage. The videotape was admitted under the "silent witness" theory, pursuant to which videotapes and photographs may be admitted as substantive, rather than merely demonstrative, evidence. For substantive videographic evidence to be admitted under this theory and be permitted to "speak for itself," there must be a strong showing of authenticity and competency. The defense acknowledged that the testimony "demonstrat[ed] the

manner in which [the video] was compiled and the chain of custody from the computer to the police department and use in this trial" but argued that because no witness with personal knowledge of the accused's actions inside the store testified, the State failed to establish the authenticity of the recording. The Court ruled that even if it were to conclude that the testimony was erroneously permitted, the error was harmless. The jurors were able to view the surveillance footage for themselves and draw their own conclusions. Therefore, the court found no reversible error on this basis.

State v. Haight-Gyuro, 218 Ariz. 356 (2008)

- Followed by State v. Williamson, 2015 Ariz. App. Unpub. LEXIS 922 (2015)

This case was about whether or not the trial court erred in allowing the state to play a video of the meetings between the undercover officers and the Defendants where the video had incorrect and allegedly inflammatory subtitles selectively added to the video. Subtitles had been added because the audio was difficult to hear. Testimony provided by firsthand witnesses declared that the transcription or the words below the videos were fair and accurate. It was therefore determined that the trial court did not err in allowing the video to be shown to the jury, or in denying the subsequent motion for a mistrial. Moreover, even assuming for the sake of argument that the trial court erred, any error would have been harmless. "Error is harmless if the reviewing court can say beyond a reasonable doubt that the error did not contribute to the verdict." Here, the Court directed the state to explain to the jury that the subtitles were of what was believed to have been said. Any harm created by the subtitles was overcome by testimony, the trial court's admonition, cross-examination of transcriber, and defense counsel's closing argument. It was concluded that any error, if such occurred, was harmless.

- Followed by State v. Coletti, 2011 Ariz. App. Unpub LEXIS 1405 (2011)

This theft by deception case involved the Defendant going to a store, putting a vacuum cleaner in his cart, and then "returning" it in exchange for a gift card. The video surveillance system in the store recorded Defendant's actions. After conviction, the Defendant appealed, arguing that the trial court erred in admitting the surveillance video where no witness testified that it accurately depicted the events at issue. The State disagreed and argued that the manager's testimony sufficiently authenticated the video. Furthermore, the State identified the Defendant by using the number on the state-issued identification provided to the store employee, and the Defendant's acknowledgment to the police officer that "he did do this," and that "he returned [the vacuum cleaner] for the money." The primary purpose of showing the video to the jury, therefore, was not to identify the Defendant, but rather to permit the jury to observe his actions leading up to the return of the vacuum cleaner.

Contrary to the Defendant's arguments, in order to authenticate the video, the State was not required to call the employees who were involved in the transaction, nor to present evidence of the Defendant's appearance on the day of the incident. Accordingly, it was concluded that the trial court sustainably exercised its discretion when it ruled that the video was properly authenticated, and that the CD could be played for the jury and admitted into evidence.

Washington v. State, 406 Md. 642 (2008)

- Followed by People v. Taylor, 398 III. App. 3d 74, 922 N.E.2d 1235, 2010 III. App. LEXIS 83, 337 III. Dec. 658 (III. App. Ct. 2d Dist 2010)

In this theft case, the Defendant was a handyman at a high school. School administrators met with a police detective about thefts. To investigate the losses, the detective purchased a "wireless camera," a "digital transmitter," and a "digital video recorder" from a store. He hid the equipment in an office used by the dean of students. A few days after the devices were activated, they recorded a person taking money from an office. Defendant was later charged regarding the incident with theft of property. After conviction, the appellate court found that even though the evidence presented sufficiently supported his conviction, the State did not lay a proper foundation for admission of the videotape of the offense. The appellate court found that so-called "silent witness" authentication of a demonstrative piece of evidence had to include testimony as to the (1) capability of a device for recording; (2) competency of the operator; (3) proper operation of the device; (4) preservation of the recording with no changes, additions, or deletions; and (5) identification of the speakers. On lack of this authentication, the conviction was overturned.

- Followed by People v. Tuncap, 2014 Guam 1, 2014 Guam LEXIS 2 (2014)

Defendant was arrested in this robbery case when the police blocked his car and drew their weapons at him. Defense argued that a surveillance video was improperly admitted into evidence because the officer's testimony provided

insufficient facts to authenticate the video. It was argued that it was an error for the trial judge to admit the CD containing the surveillance video into evidence because there was no testimony regarding "the type of equipment or camera used, its general reliability, the quality of the recorded product, the process by which it was focused, or the general reliability of the entire system." The court found no abuse of discretion in refusing to admit a tape recording for which there had been no authenticating testimony whatsoever.

England v. State, 940 So.2d 389, 2006 Fl

- Followed by Yero v. State, 138 So.3d 1179, 2014 Fla. App. LEXIS 7701, 39 Fla. L. Weekly D 1060 (Fla. Dist. Ct. App. 3d Dist. 2014)

A Defendant charged with grand theft for stealing a woman's wallet from her purse in a bar failed to prove a due process violation based on the destruction of the bar's surveillance video, which officers testified showed Defendant standing near the purse with a flat pocket, then with a wallet-shaped bulge in his pocket. Defendant maintained that the trial court erred in failing to exclude the testimony describing the content of the video. The best evidence rule states "[t]he original of a writing, recording, or photograph is not required…and other evidence of its contents is admissible when…[a]ll originals are lost or destroyed, unless the proponent lost or destroyed them in bad faith." Because the surveillance video was not exculpatory and because the State did not act in bad faith when it failed to preserve it, the trial court properly denied the motion to dismiss the information.

CANADIAN CASES

Makara v. Weihmann, [2005] B.C.J. No. 2972

- Deventer v. Woods [2009] B.C.J. No. 2263

This case was about injuries allegedly suffered as a result of an automobile accident. Defendant asserted that admitted photographs were not relevant because there was no expert evidence linking the extent of the damage to the vehicles to the extent of the injuries to the Plaintiff. A related issue was whether the probative value was outweighed by the prejudicial effect those photographs would have on the jury. The court noted that the photographs were not anything other than neutral in their composition. They did not attempt to downplay or overstate the damage that occurred in the collision. According to the driver of the car in which the Plaintiff was traveling, they accurately portrayed the damage, as he saw it, following the crash. The Plaintiff argued that given the photographs' potentially limited assistance on the matters in issue, there was a risk they would be misused by the jury. The concern was that the jury would infer from them more than ought to be inferred. On the issue of whether the probative value of the photographs in this case was outweighed by their prejudicial effect on the jury's assessment, the court's view was that such prejudice could be adequately addressed by way of appropriate instructions to the jury. Such directions would not simply be to ignore the photographs, as Plaintiff's counsel argued, but rather, a direction to put the pictures into the context of the evidence as a whole. The pictures were one piece of evidence about the impact and the vehicles, as was the Plaintiff's evidence. There would also likely be a direction that the fact that no or little damage occurred to vehicles did not mean that a Plaintiff cannot be injured. The court concluded that the photographs were admissible, subject to objections about their authenticity or accuracy.

R. v. Bartkowski et al., [2004] B.C.J. No. 2947

- R. v. Sipes, [2011] B.C.J. No. 2759

Two Defendants were charged with second-degree murder relating to the beating death of a victim. Four additional Defendants were charged with first-degree murder relating to the shooting death of a second victim. This application concerned the admissibility of various photographs of the injuries suffered by the victims, including autopsy photographs, as well as photographs and a video of the murder scene. With regard to three hospital photographs of the first victim, all were deemed necessary to assist the jury to understand what transpired. The probative value of the three photographs taken at the hospital outweighed the minimal prejudicial effect. They were deemed admissible. With regard to the second victim, Defendants objected to the admissibility of five autopsy photographs, two crime scene photographs and a brief segment of the video of the crime scene on the basis they were graphic, repetitive, and unnecessary. The court was satisfied that the photographs would assist the jury in understanding and assessing the evidence of the pathologist and in assessing the positioning of the victim's body in relation to the alleged shooters. The probative value of the photographs outweighed their relatively minimal prejudicial effect. The court concluded that the five autopsy photographs were admissible. The photographs and the video segment were also deemed potentially relevant

as they served to corroborate a witness whose credibility will undoubtedly be seriously challenged at trial. The photographs and video may assist the jury in assessing his evidence as to what occurred at the scene. The video evidence of the scene was deemed to provide an additional perspective to that provided by the photographs. The court deemed the probative value of the photographs and video segment of the crime scene to outweigh their relatively minimal prejudicial effect. The crime scene photographs and the video segment (9:35 to 11:05) were admissible.

R. v. McLeod, 2005 ABQB 842—[2005] A.J. No. 1571

- R. v. Barton, [2015] A.J. No. 541

This case involved a murder. At issue was potential prejudice to the accused by the introduction of graphic depictions of evidence: It was ruled that "the Crown was entitled to tender some photographs of the scene [the victim's] body was found in order to provide the context" Some photographs were excluded on the basis that they had little probative value on the issues of identity and intent, which were the issues at that trial.

- R. v. Khairi, [2012] O.J. No. 4650

The accused was charged with having murdered his wife. It is not disputed that he stabbed her several times and, more importantly for purposes of this ruling, that he cut her throat. The only real issue at trial was the intent of the accused in inflicting the wounds that caused the victim's death. The Crown wished to adduce a number of photographs showing the deceased's body both in situ and at autopsy. Counsel agreed that all but one of the proposed photographs were properly admissible. A brief *voir dire* was conducted to determine the admissibility of the single, disputed photograph. The Crown's pathologist postulated that death was caused by exsanguination and the throat wound was the principal mechanism of death. Several of the agreed upon photographs depicted this wound; almost without exception, they depicted it only as a narrow lateral opening across the front of the neck. The photograph in dispute, however, was taken at autopsy with the deceased's head deliberately articulated backward, so as to cause the wound to gape. The photograph was taken at very close range, such that, apart from a small amount of surrounding skin, all one sees is a large opening revealing the inside of the throat. The purpose of posing the head in that fashion, as I understand it, was to expose certain injuries to the internal structures of the neck, not visible in the other photographs, and, more importantly, not capable of being fully depicted by any other means. The Crown contended that the photograph would assist the jury in correctly deducing the accused's intent at the time he killed his wife. That is so because the photograph will help them to better understand, among other things, the pathologist's evidence concerning the amount of force that would be necessary to cause the wound. Knowing the force required might, in turn, put them in a better position to decide the question of intent. While Crown counsel acknowledged that the photograph is somewhat disturbing, it determined that its probative value outweighed any potential prejudicial effect it may have.

- R. v. Nodrick, [2010] M.J. No. 399

Defendant was charged with first-degree murder; he was said to have committed the murder in the course of an unlawful confinement. At issue was the admissibility of six photographs of the deceased. Counsel agreed that, with the exception of the six photographs that were at issue, the books of photographs that were tendered at the preliminary inquiry were to be evidence at the trial. These photographs depicted the deceased's body in the field when found by the police and during the autopsy. Many of these photographs showed the deceased's body, bruised, injured and decomposing, naked (with underwear in those taken in the field), and covered in maggots. Defense counsel objected to the admission of photographs which were also of the deceased in the field and during autopsy, but which showed his face covered in maggots. It was agreed that the photographs at issue were accurate, fair, and authentic. The objection to their admission was on the basis that their prejudicial effect outweighed their probative value. The Crown was of the opinion that if admitted, there is a significant danger that these six photographs would interfere with the jury's task of dispassionately weighing the evidence, even with careful instruction from the bench. Further, and significantly, the prejudicial effect of the six photographs outweighed their probative value and therefore they should not be admitted into evidence. This ruling could be revisited depending upon how the evidence developed at trial.

R. v. Trakas, 2007 ONSC 35294—[2007] O.J. No. 3240

- R. v. Lavoie, [2014] J.Q. No. 17411

Defendant, accused of first-degree murder, asked to be excluded from evidence certain photographs taken at the scene were found where different parts of the dismembered body of the victim. Defendant argued that the admission of these photographs was not necessary. He argued that the nature and consequences of the injuries sustained by the

victim were not in dispute and that the horror of these photographs could bring him great harm. The prosecution contended that these photographs would corroborate witness testimony by an alleged accomplice who would testify for the prosecution in this case. Moreover, injuries shown in the photographs would allow the jury to draw certain inferences about the degree of force used in the murder.

Motion was granted in part. Photographs could reasonably be expected to establish a link between the injuries suffered by the victim and weapons possibly used against him. The photographs exposing the head of the deceased could allow a jury to draw some conclusions about the degree of force used at the expense of the victim. They would be particularly likely to assist the trier of fact to determine whether the injuries resulted from blows inflicted by a woman or a man of stature comparable to that of Defendant. A review of close-ups of the head of the victim satisfied the Tribunal to him alone, the testimony of the pathologist would not allow the jury to properly assess the nature and extent of lesions. Although the photographs were horrible, they were not unsustainable to the point of distracting the jury from its duty to judge Defendant justly, fairly, and impartially. Final guidelines and mid-trial do much to eliminate any possibility of prejudice generated by an emotional reaction of jurors. To further limit the extent of the potential harm, the Court ordered the exclusion of seven photographs it deemed repetitive.

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Appendix

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TIPS, TRICKS, AND MACGYVERS

As we have mentioned throughout this book, law enforcement types, and especially crime scene investigators, have a very special "I can do that!" attitude. CSI types can not only duplicate the efforts of others before them but also often pride themselves on being able to get the job done with make-shift equipment, costing far less than what can be purchased through crime scene product catalogs. Hence, the term "MacGyvers": With a bit of string, a paperclip, and, of course, some duct tape, CSIs can get almost any job done! Just one example will convince the doubtful. When expensive lasers were first used at crime scenes to induce fluorescence in many varieties of evidence, a senior CSI in a neighboring jurisdiction found an old slide projector about to be thrown away, glued a blue filter over the lens, and created his own alternate light source. Most items of evidence stimulated by the laser into fluorescence also fluoresced with the modified slide projector.

In addition to these pure MacGyvers, the ingenuity of CSI photographers can manifest in many other ways. While this book attempts to cover most of the photographic needs of crime scene photographers, this author is convinced there are numerous examples of the resourcefulness of other photographers still undiscovered—which leads to this challenge: If you have a photographic tip, trick, or MacGyver, share it! Send it to this author, and if we are fortunate enough to have a fourth edition of this book, as many as possible will be included in this appendix. Of course, all submissions will be properly attributed to the sender. Send your MacGyvers not just to get your name published; do it so that others can benefit from your suggestions. Let us use our cameras to put more bad guys away! As we have said before, the more tools you have on your Bat-Belt, the more problems you will be able to solve as they are encountered. Examples follow.

Evidence on Vertical Walls

In one *Journal of Forensic Identification* article (Vol. 56, No. 1, January–February 2006), an author was describing a case where, as a victim was going over a rooftop, there were bloody finger marks left on the wall, obviously an attempt to grasp at anything to prevent the fall. The article was about attempting to maximize the depth of field so the entire 3′ length of bloody finger marks would be in focus when the photographer was standing on the roof and peering down to take the photo. The JFI author recommended using a Tilt-Shift lens to increase the depth of field with this angled shot. The challenge had been laid out. This author's creative juices began to flow after reading this article, with the need to capture the entire 3′ length of evidence in focus without using a Tilt-Shift lens being the challenge. The MacGyver deep inside this author surfaced. Through the use of normally available photographic equipment, a paperclip, and some duct tape, the problem was solved!

The solution was to mount a camera onto a tripod, secure the tripod's weight with "ropes" of duct tape, and lower the tripod over the side of a wall with its three feet on the wall and the camera's film plane parallel to the wall. The camera would be prefocused so that a length of 3′ was in focus. The 10-s delayed shutter option would be used, so that once the shutter was pressed, it would be necessary to position the tripod over the evidence in the 10 s available. A paperclip was taped to a stick to help position each of the three tripod legs over the evidence, so the camera was properly positioned to capture the evidence. If this approach was successful, then naturally the entire 3′ length of evidence would be in focus. Real rope, of course, was shunned because MacGyver would never use real rope! Regular duct tape needed reinforcing, so four thicknesses of tape were used to make sure the tape did not break, taking an expensive camera and lens to a premature death. To simulate 3′ of bloody fingerprints, six full handprints were used. If this procedure was successful, it would be good to show close-ups of the fingers with detail in focus. Of course, this entire procedure could have been repeated with the tripod legs shortened to their most compact position for better close-ups, but this was not the original challenge. Capturing 3′ of evidence with detail in focus was the challenge.

Fig. A.1 shows this author in the process of capturing the shot. Naturally, several tries were needed for success, with only 10 s available before the shutter tripped. However, success was obtained.

Have you done anything similar?



FIGURE A.1 Collage of images showing the author setting up a tripod on a vertical wall to photograph evidence with a uniform DOF range; close-ups demonstrate ridges are captured in focus.

Coaxial Lighting

When untreated fingerprints are on glossy surfaces, like credit cards, lighting them with oblique lights is frequently unsuccessful when you are trying to visualize them for photography. Moving a flashlight around by trial and error usually results in the fingerprint best visualized with the flashlight aimed almost straight down at the print. Of course, when the camera is directly over the fingerprint, with the film plane parallel to the fingerprint, the flash or flashlight cannot also occupy that same position. Or can it? If you use a technique called coaxial lighting, both the camera's position and the light used to visualize the fingerprint can occupy the same space. How can the light be positioned so it is shining straight down on the fingerprint, 90 degrees to the surface, when the camera is there also? You must bend the light!

To bend the light, use a clean sheet of glass, held at a 45-degree angle to the fingerprint, with a flashlight positioned parallel to the surface with the fingerprint on it. The light then comes in from the side of the print, strikes the glass, is reflected straight down toward the fingerprint, lights the fingerprint, and is then reflected straight up through the glass into the camera lens.

Figs. A.2–A.7 show this set-up, as a graphic and with photos of coaxial lighting being used. Figs. A.3–A.5 demonstrate the technique being used to visualize an untreated fingerprint on slides. But, how many times have you found a fingerprint on a slide at a crime scene? Fig. A.6 shows the technique being used to direct light straight down into a CVS card; other credit cards would work the same. Fig. A.7 shows the technique being used to visualize the contents of a film canister. Otherwise, with an electronic flash held to the side of the camera, there is partial shadowing within the canister. Of course, it would also be possible to pour the contents of the film canister out onto the table and photograph them all then. Coaxial lighting is merely another solution to solve the problem.

Have you done anything similar?

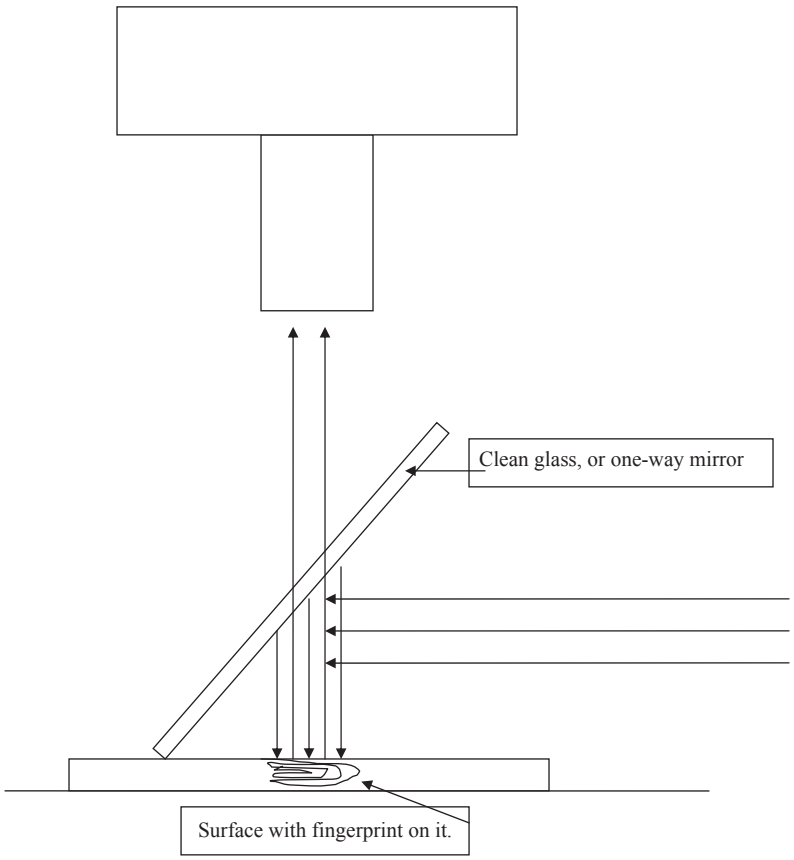


FIGURE A.2 Graphic showing the coaxial lighting set-up.

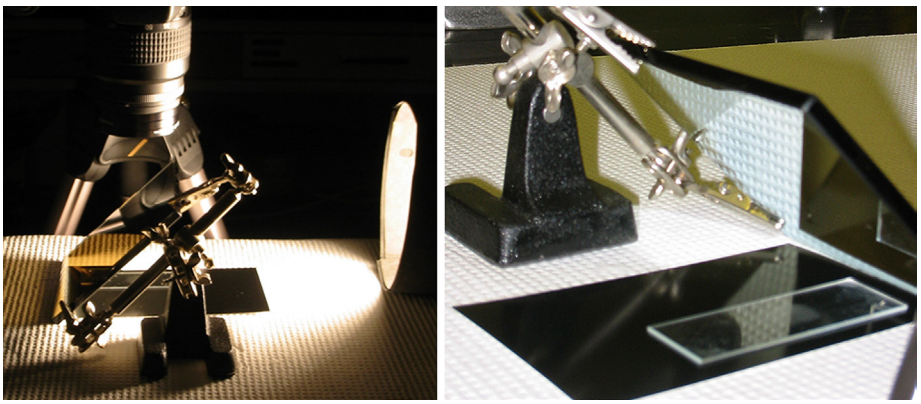


FIGURE A.3 Coaxial lighting set-up: with mirror held by clamps.

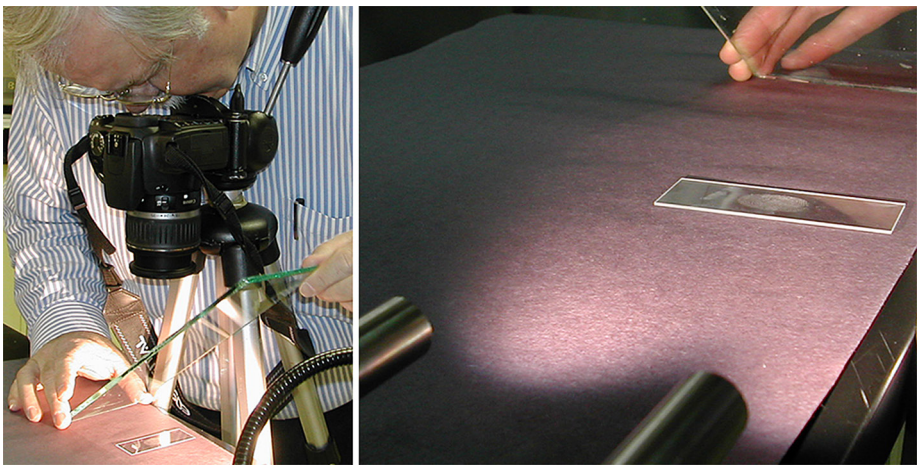


FIGURE A.4 Coaxial lighting set-up: with mirror held by hand.

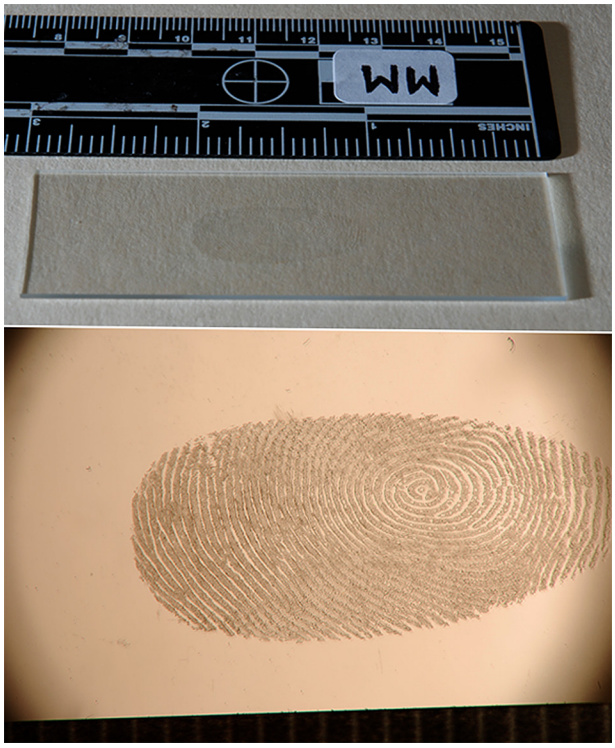


FIGURE A.5 Coaxial lighting results with latent on a slide.



FIGURE A.6 Coaxial lighting results with latent on CVS card.

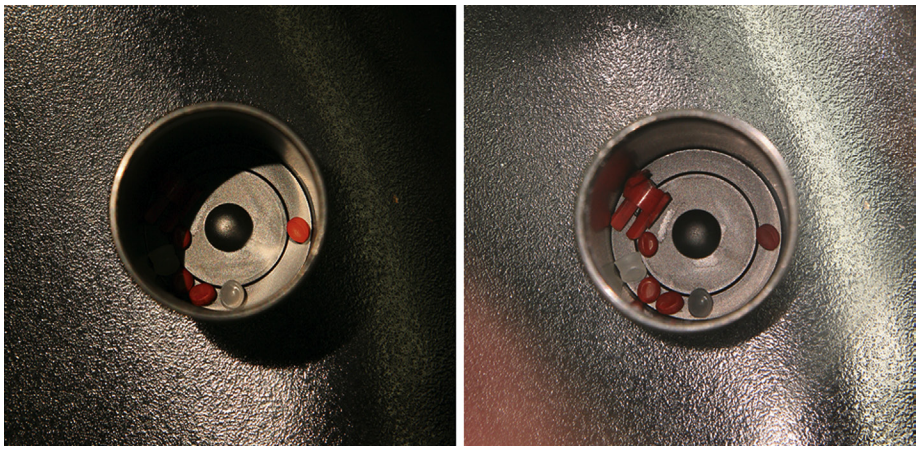


FIGURE A.7 Coaxial lighting bending light down into a film canister.

Mirrors

Evidence on mirrors presents other difficulties. To photograph the evidence with the film plane parallel to the surface of the mirror, the photographer will be in his or her own field of view. To avoid this, one option is to photograph the evidence from a slight angle and then use computer software, like Photoshop to "fix" the perspective distortion.

Fig. A.8 shows this sequence. But sometimes even a slight photographic angle is to be avoided. If the evidence is a fingerprint or a shoe print, if a slight angle is used to photograph the evidence, frequently an annoying duplicate image of the evidence will also be photographed. The evidence on the surface of the mirror and a reflection of the evidence on the mirror's silvering will be captured at the same time!

Fig. A.9 shows this possibility. Perhaps the shoe print analyst can still see the detail necessary to make an identification. However, if the photographer were just a bit more resourceful, a better image can be captured. How? By having the film plane parallel to the shoe print when the photo is taken. The trick is to avoid having the photographer and camera equipment in view when this is done. This is managed by cutting a small hole in a sheet of poster board and taking the photograph with the poster board between the photographer and the surface with the shoe print. The hole in the poster board needs to be only dime-sized or even smaller. As was mentioned in an earlier chapter, comparison-quality photographs are taken with an f/11 aperture. It is not necessary to have the hole on the poster board be the

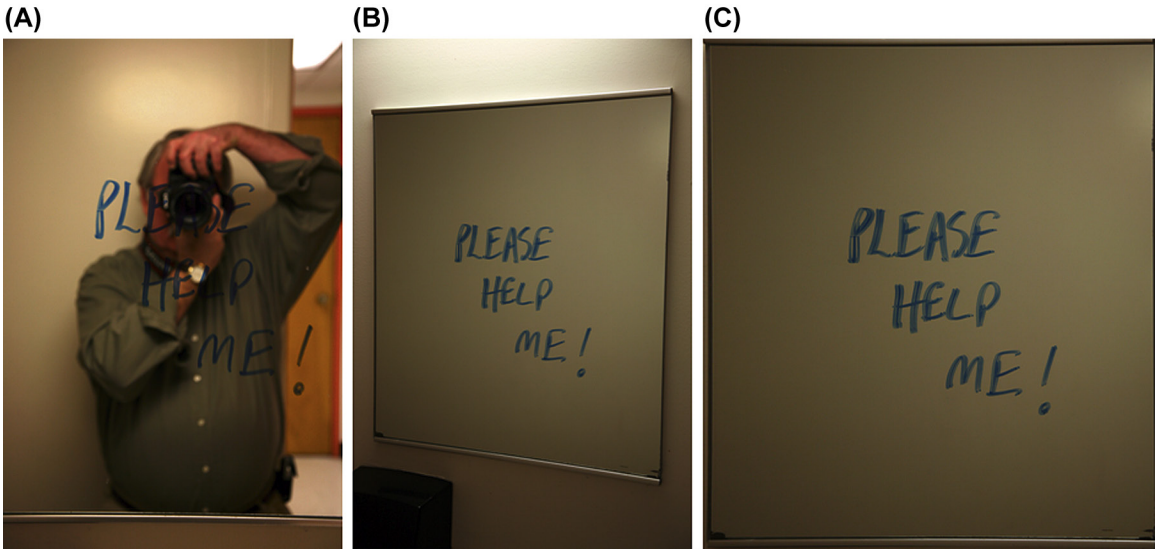


FIGURE A.8 Mirror shots: (A) incorrect; (B) an angled shot to avoid appearing in your own photograph; (C) a Photoshop "correction" of the angled shot.

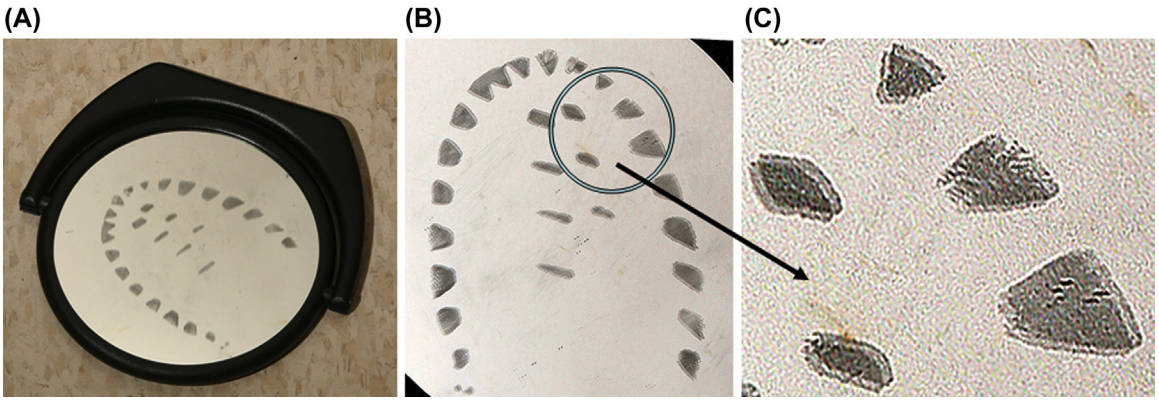


FIGURE A.9 Angled mirror shots: (A) angled view of a shoe print on a mirror; (B) same shoe print; (C) the angled view captures a "double" view, making IDs difficult.

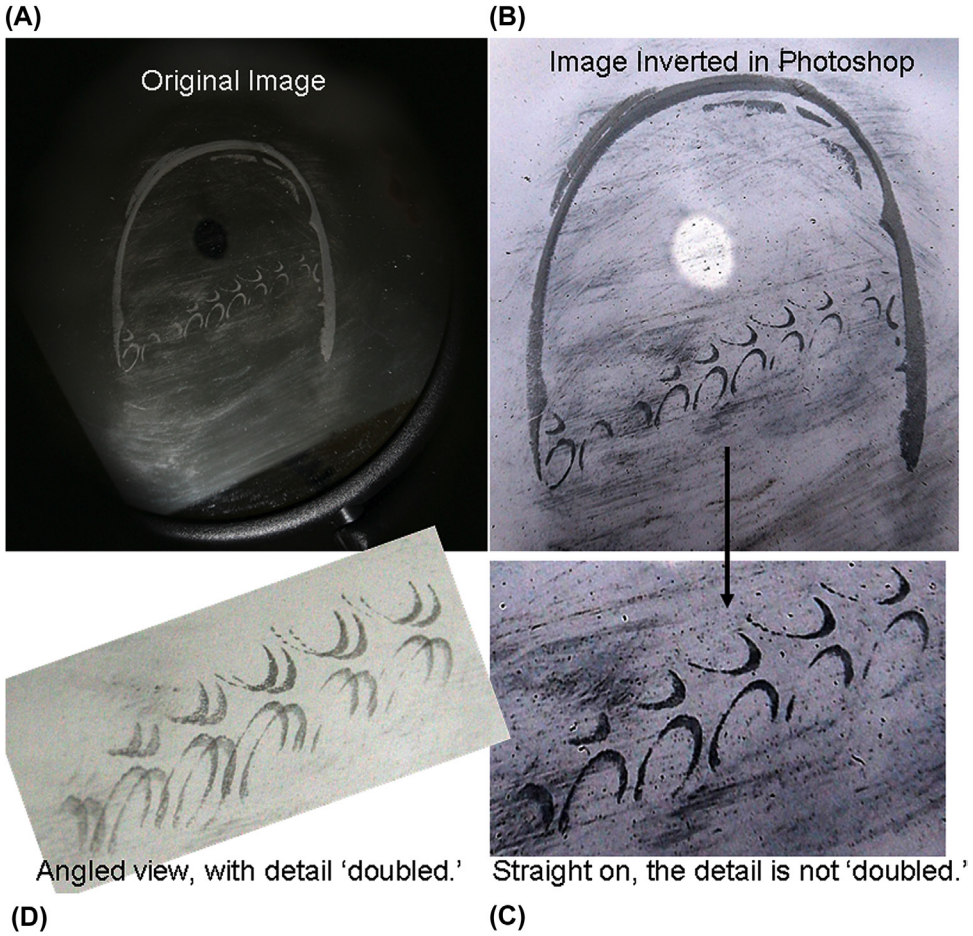


FIGURE A.10 Straight-on mirror shots: (A) photograph through hole in poster board; (B) same image inverted; (C) close-up—no "double" image; (D) "double" image from an image like Fig. A.9.

entire size of the front of the lens. It is necessary only to have the hole approximately the same size as the aperture used. The poster board will then block the photographer and the camera from being captured in the photo. What will be captured in the photograph is the hole in the poster board. That is unavoidable, but not a problem. While viewing the evidence through the viewfinder, you will see both the evidence and the hole. Merely arrange the hole so that it is positioned within the shoe print in an area without detail. Fig. A.10 shows the result.

Fig. A.10 also shows a side-by-side comparison of an angled view of the shoe print detail and a straight-on shot of the shoe print detail. The straight-on shot is much preferred. Your shoe print examiner will bless you! Since Photoshop was used to invert the original light-colored image to a dark-colored image, to make the comparison process easier, some have suggested that Photoshop can also be used to "clone" out the hole altogether. This author disagrees with that suggestion. Leave the hole in the image, proud and prominent. If the defense attorney makes the mistake of asking what that strange shape is, you will then be able to answer the question, explaining your expertise and command of your tools. Since the defense attorney's job is to avoid bolstering your credibility, fewer questions will be coming your way from that defense attorney. Leave the hole there as a trap!

Have you done anything similar?

Distortion Correction, Redux

Despite the fact that this text is not intended to be a Photoshop "processing" how-to book, simple "fixes" can be mentioned in this appendix. It is well known that photographing the exterior of buildings, particularly with wide-angle lenses, will result in the photographs of the buildings showing some perspective distortion. Look at the two examples in Fig. A.11.

This distortion occurs so frequently that you may even fail to notice it, although it is certainly obvious. This is a "normal" result of viewing the buildings from the ground level. The top of the buildings will always appear to be narrower



FIGURE A.11 Two "distorted" images of buildings.



FIGURE A.12 Photoshop "crop," showing Perspective box checked to align image edges with building walls. Adobe Photoshop CS2 screen shot reprinted with permission from Adobe Systems Incorporated.



FIGURE A.13 Photoshop geometric corrections to buildings in Fig. A.11.

at the top of the structure. Photoshop CS2 has very simple "fixes" for this type of distortion. When you use the Crop tool, once the cropping rectangle has been placed on the image, it is common for the sides and the top and bottom lines of the cropping rectangle to be moved as desired to crop irrelevant details. With Photoshop CS2, when the Crop tool is selected, a "Perspective" box also appears at the top of the screen. When you check this, you can alter the cropping rectangle by moving its corners. The corners can be aligned with the natural features of the scene—for example, the four sides of the building. See Fig. A.12.

Now, when the image is cropped, not only will the material outside the cropping rectangle (which is no longer really a rectangle) be eliminated, but the angled sides of the cropping rectangle will be forced back into a true rectangle, thereby correcting the distortion to the building. See Fig. A.13.

Nice straight walls; nice upright trees and light poles!

Have you done anything similar?

DARKFIELD ILLUMINATION

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Darkfield illumination is a photographic technique used by forensic technicians to document bullet hole evidence in glass. When a bullet travels through glass, various radial and concentric cracks form in the glass. Analysis of these cracks may be conducted to ascertain the sequential shots that were fired. A photograph that displays the contrast of the cracks to the glass is desirable. The positioning of the light source allows the detail of the fracture lines to be accentuated while simultaneously darkening and removing distracting objects located beyond the glass.

First, photograph orientation views of the bullet hole evidence in relationship to the rest of the crime scene. Darkfield illumination may be applied for both medium distance and close-up (macro) views of the bullet hole(s). The procedure is as follows:

1. Place the camera on a tripod. Position the tripod on the side of the glass that the bullet traveled (if known). The camera back (or front element of the lens) must be parallel to the bullet hole. A level may be used for vertical or horizontal surfaces.
2. Place a scale on the same surface as the bullet hole(s), preferably placed both horizontally and vertically around the bullet hole(s).
3. Place a continuous light source (eg, photographic flood lamp) on the opposite side of the glass as the camera and tripod. Direct the light source toward the bullet hole at a 45-degree angle. Darkfield illumination should be conducted under dark conditions in order for the effect to be achieved. The interior lights should be off, and the exterior (outside) should be fairly dark to achieve optimal results.
4. The camera lens must be parallel to the bullet hole. A level may be used for vertical or horizontal surfaces (see Fig. B.1). If the surface is angled, an angle finder should be used. An angle finder is a device sold within standard



FIGURE B.1 Example of a vertical surface (paned wood and glass door) in which darkfield illumination could be utilized with an angle finder to determine the angle of the glass. Photo courtesy of Tina Young.

bullet trajectory kits used to find the up/down angle of a bullet's trajectory (bullet's path). The device can also be used to obtain the up/down angle of various surfaces such as angled walls, car windshields, sloping pavements, and other surfaces (see Fig. B.2). For bullet hole evidence, the angle finder is placed on the surface of the bullet hole. The same angle is used for the camera so that the lens remains parallel to the bullet hole (see Fig. B.2).
5. Use the appropriate camera settings, good depth of field (F-11 or F-16), ISO 200 or 400, tungsten white balance, and adjust the shutter speed for proper exposure. Bracket the exposure. Press the shutter release button.
6. The resulting image should display the bullet holes with a dark background.

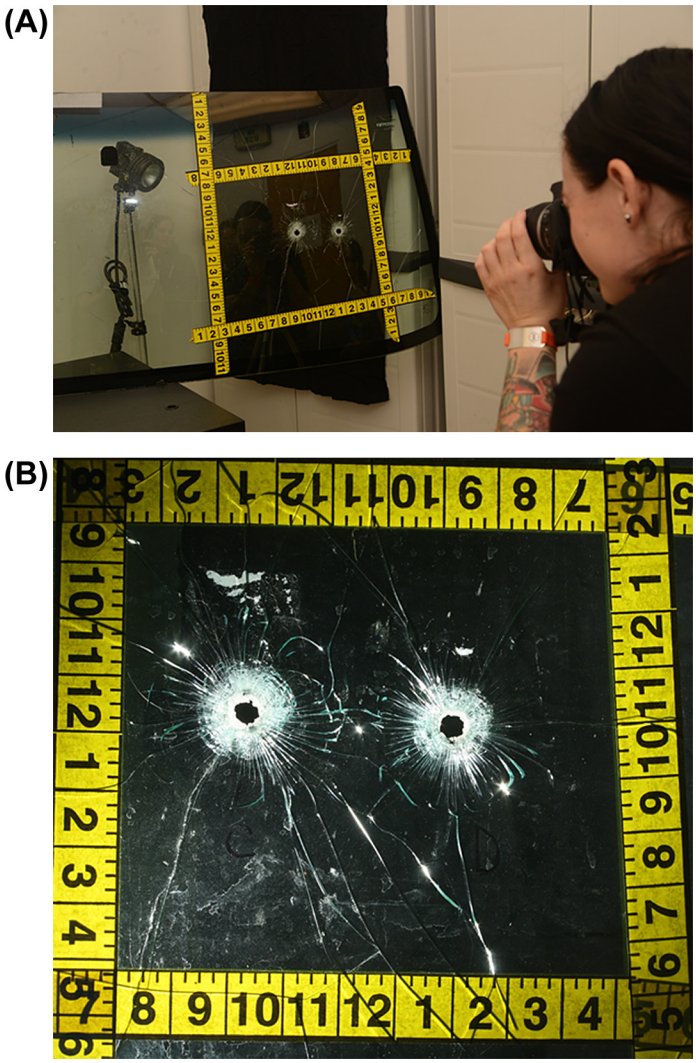


FIGURE B.2 (A) Composing the darkfield image of bullet holes. *(Photo courtesy of Tina Young.)* (B) Darkfield image of bullet holes. *(Photo courtesy of Grossmont College student, Kimberly Sid Weber.)*

BLACK SHIELD PHOTOGRAPHY

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For highly reflective surfaces, such as a mirror, a black shield can be used to prevent hot spots in a photograph. The following steps are recommended.

1. Position continuous lighting (photographic flood lamps) at a 45-degree angle to the reflective surface (such as a mirror). All overhead lights should be turned off.
2. Position a camera equipped with a macro lens directly above the evidence. The face of the camera lens must be parallel with the evidence. Attach a shutter release cable.

3. Using a piece of black cardboard or other black shield with a hole large enough to accommodate the camera lens, position the shield in front of the camera with the lens protruding through the hole of the shield. If using a photographic card that is black on one side and white on the opposite side, ensure that the black side is face-down toward the evidence. The photographic lamps should be positioned below the black shield. Hold the shield in place with clamps connected to the stand. The shield may be handheld if clamps are not available.
4. The shield should prevent excess light from entering the camera lens and creating hot spots.
5. Use the appropriate camera settings, ISO 100 or 200 (if photographing fingerprints or evidence that will be compared to a known sample), tungsten white balance, and adjust the shutter speed for proper exposure. If photographing a fingerprint on a mirror, start with poor depth of field and gradually increase the depth of field to ensure that the detail of the print can be seen, but a double reflection of the print in the mirror cannot be seen. Take macro photographs with and without a scale in the image (Siljander, Raymond, and Fredrickson, 1997; Young, Tina, and Ortmeier, PJ, 2011) (Fig. B.3).

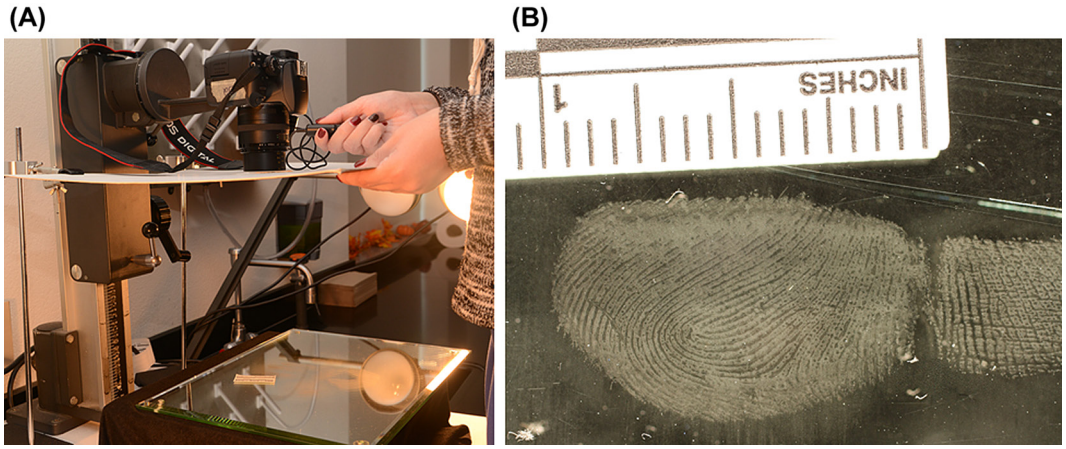


FIGURE B.3 (A) Photographic set-up using a black shield. *(Photo courtesy of Tina Young.)* (B) Resulting fingerprint using Black Shield technique. *(Photo courtesy of Grossmont College student, Julia Underwood.)* Example of an angled surface in which darkfield illumination could be utilized. *(Photo courtesy of Tina Young.)*

Further Reading

Siljander, R.P., Fredrickson, D., 1997. Applied Police and Fire Photography, second ed. Springfield: Charles C. Thomas Publisher.

Young, T.R., Ortmeier, P.J., 2011. Crime Scene Investigation: The Forensic Technician's Field Manual, Columbus: Pearson Prentice Hall.

HIGH DYNAMIC RANGE

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Forensic photography has been evolving ever since the first forensic photograph was taken over 100 years ago. The evolution has continued from film to almost entirely digital photography in forensics. With this age of digital photography, we now have an advantage over film with the ability to capture forensic images and being able to view them right after an image has been taken. We now can see if the image we captured has the needed detail to make an excellent forensic image. With the use of computers and digital cameras, we are able to adjust the overall tonal range of an image using the high dynamic range (HDR) technique.

Reproducing the full range of tones or brightness values seen by the human eye is one of the most fundamental challenges in photography. (Digital PhotoPro).

High dynamic range is defined as follows: In image processing, computer graphics, and photography, high dynamic range imaging is a set of techniques that allow a greater dynamic range of luminance between light and dark areas of a scene than normal digital imaging… (en.wikipedia.org/wiki/High_dynamic_range_imaging).

Dynamic range is defined as follows:

What is dynamic range? In imaging, dynamic range (DR) is the highest overall level of contrast found in an image. In other fields, such as in the audio industry, dynamic range is used to describe similar phenomena. In audio, DR is defined as the logarithmic ratio between the largest readable signal and background noise. Imaging DR is akin to audio signal-to-noise ratio. Consider an image a signal. Every image also has some noise. The values used to specify dynamic range can be charted on multiple scales. Whatever language is used to describe this phenomenon, two critical factors must be addressed—the total range of brightness and the fineness of the steps used within the scale. (Digital PhotoPro).

So what exactly is the HDR technique? HDR is photographing at least three bracketed photographs (see Figs. C.1–C.3) of the same scene and then combining them in either Adobe Photoshop CS4 or Photomatix Pro software (see Fig. C.4). The three bracketed shots capture the mid-tones in the normal exposure, the overexposed shot captures the shadow areas, and the underexposed shot captures the highlights. This combination produces a 32-bit image; this image is four times the size of an 8-bit file, which then can be color-corrected for brightness, color, and contrast, thus producing an image with an excellent tonal range.



FIGURE C.1 Underexposed –1 EV. Photo courtesy of King C. Brown and M. Dawn Watkins.



FIGURE C.2 Overexposed +1 EV. Photo courtesy of King C. Brown and M. Dawn Watkins.

Shooting Suggestions Using High Dynamic Range Photography Technique

SHOOT RAW FORMAT

Many photographers today have the capability to shoot in the RAW format; however, they choose to shoot in .JPEG for convenience. Granted, you shoot fewer photographs on your camera when using RAW due to the image size, and RAW files take up more hard drive space. But let us be realistic; .JPEG images are processed data from RAW data captured by your camera. This processed image also loses bit depth 12~16 to 8 in the .JPEG format. You end up with 32–256 times less brightness levels to work with when using JPEG.

SHOOT AT A LOW ISO

Cameras lose dynamic range very rapidly when increasing the ISO settings. Camera sensors have the maximum dynamic range at the minimum ISO setting. So shooting at the lowest ISO setting produces the highest dynamic range in the image, thus preserving the details of the image (recommended 100 or 200 ISO).



FIGURE C.3 Normal exposure. Photo courtesy of King C. Brown and M. Dawn Watkins.



FIGURE C.4 Combination HDR photograph using Photomatix Pro 3 Software. Photo courtesy of King C. Brown and M. Dawn Watkins.

USE THE CORRECT EXPOSURE

Be sure to use the correct exposure in your images. If you underexpose too much or overexpose too much, you run the risk of having the same level of sensor noise that is in the shadow detail, or you could clip the highlights in an overexposure. In this case you may not be able to recover the details in post processing.

Setting Up Your Camera to Shoot High Dynamic Range

For the HDR technique to work, you must first set your camera so the camera will shoot bracketed shots that can be used in a software program to create an HDR image. Photoshop has an excellent auto-align feature that allows you to photograph with or without a tripod. The area should be well lit, so you can use a high shutter speed producing images that are not blurry. In the forensic application, we strongly suggest the use of a tripod and cable release/electronic remote so that very little movement will be captured (see Figs. C.5–C.8).



FIGURE C.5 Underexposed –1 EV. Photo courtesy of King C. Brown and M. Dawn Watkins.



FIGURE C.6 Overexposed +1 EV. Photo courtesy of King C. Brown and M. Dawn Watkins.

STEP 1

Place you camera on a sturdy tripod and attach your cable release. You will need to vary your exposures with each HDR shot. Switch your camera to the aperture priority mode (use the A mode on Nikon cameras like the D300, D200, D700, D90, D2X and D3; and the Av mode on Canon cameras like the 50D, 40D, 30D, 5D, 5D Mark II, 1D Mark III). In the aperture mode, choose an f/stop like f/8 or f/11 outdoors to create the best depth of field for your lens. Indoors, use either f/5.6 or f/8; this will produce a slow shutter speed, so be sure to use a tripod and cable release/electronic remote.



FIGURE C.7 Normal exposure. Photo courtesy of King C. Brown and M. Dawn Watkins.



FIGURE C.8 Combination HDR photograph using Photomatix Pro 3 Software. Photo courtesy of King C. Brown and M. Dawn Watkins.

STEP 2

Compose your shot and focus on your scene; then switch your lens to manual focus. Do not worry; you are not going to use manual focus. You will use auto focus for each shot and then switch to manual focus to ensure that the lens does not refocus during each shot.

STEP 3

Now set up your camera to autobracketing. This feature allows the camera to shoot one exposure at the normal exposure and two exposures, one brighter and one darker. It is also suggested to perform a five-bracket exposure of one normal exposure and two brighter exposures and two darker exposures, depending on the scene you are photographing.

STEP 4

Set your camera to the continuous low shooting mode. Press the exposure button and hold it down to take the three or five bracketed shots (Nikon has three, Canon has five).

STEP 5

To turn on bracketing on a Canon camera (like the Canon 50D or 40D), start by going to the Camera Tab menu in the LCD on the back of the camera. Now scroll down to Expo Comp/AEB (Auto Exposure Bracketing), and press the Set button. Now use the Main Dial to choose 2 stops brighter, and then press the Set button again (this automatically sets the bracketing to also shoot 2 stops darker). Now set your camera to low speed continuous shooting mode, and then press and hold the shutter button. Your cameras will automatically shoot all five bracketed photos. Once all five are taken, you can release the shutter button. (For more information, see *The Adobe Photoshop CS4 Book*, Chapter 9, pp. 246–248).

Software Programs for High Dynamic Range Technique

There are several software programs for you to combine your images into the HDR format. The authors used Photomatix Pro 3 Full Standalone Version, the Adobe Photoshop Plug-in, and Adobe Photoshop CS4 Version for the sample photographs (see Figs. C.9–C.12).

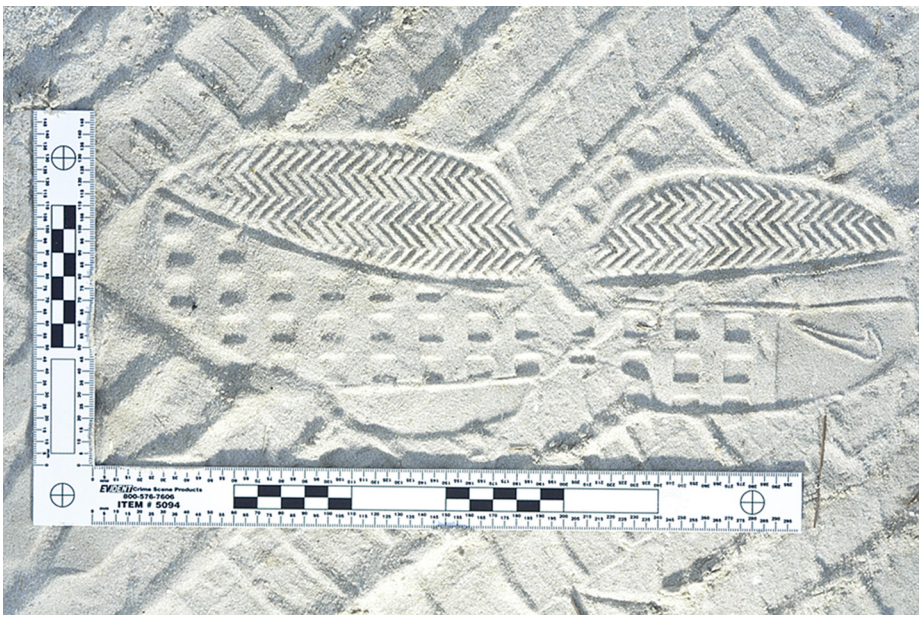


FIGURE C.9 Underexposed –1 EV. Photo courtesy of King C. Brown and M. Dawn Watkins.

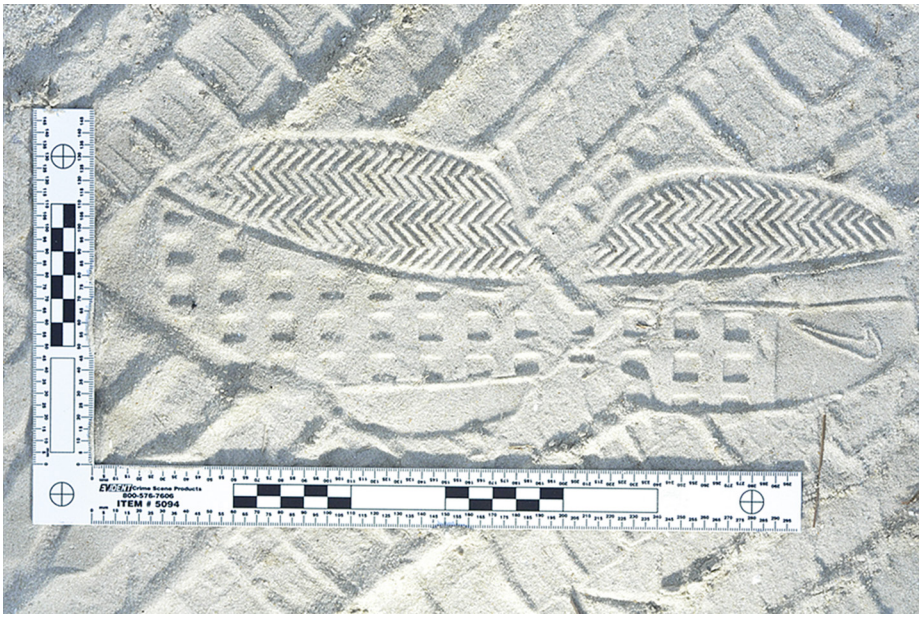


FIGURE C.10 Normal exposure. Photo courtesy of King C. Brown and M. Dawn Watkins.

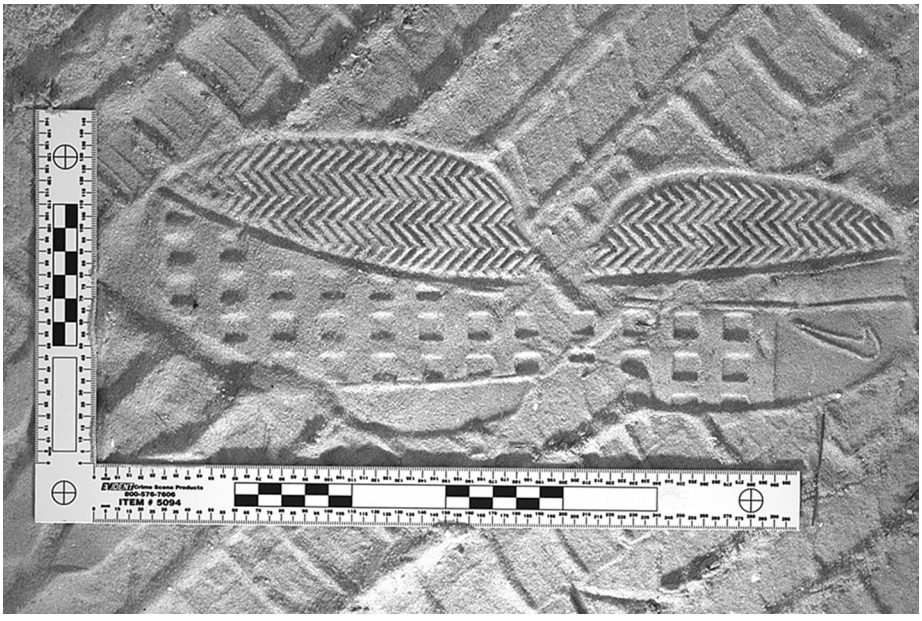


FIGURE C.11 Overexposed +1 EV. Photo courtesy of King C. Brown and M. Dawn Watkins.

One more example of HDR before we are through! Some of you may have been muttering something about the fact that fill-in flash, when done well, seems to result in something very similar to these HDR images. It is possible the author has even been known to make such vocalizations. If it is not broken, why try to fix it? And, then I sat in a presentation by MPO Marc Hackett, who is also the author of the section on Vehicular Accidents in, "chapter Special Photography Situations." During a CBD-IAI conference, Marc delivered a presentation on HDR photography which has made me a believer.

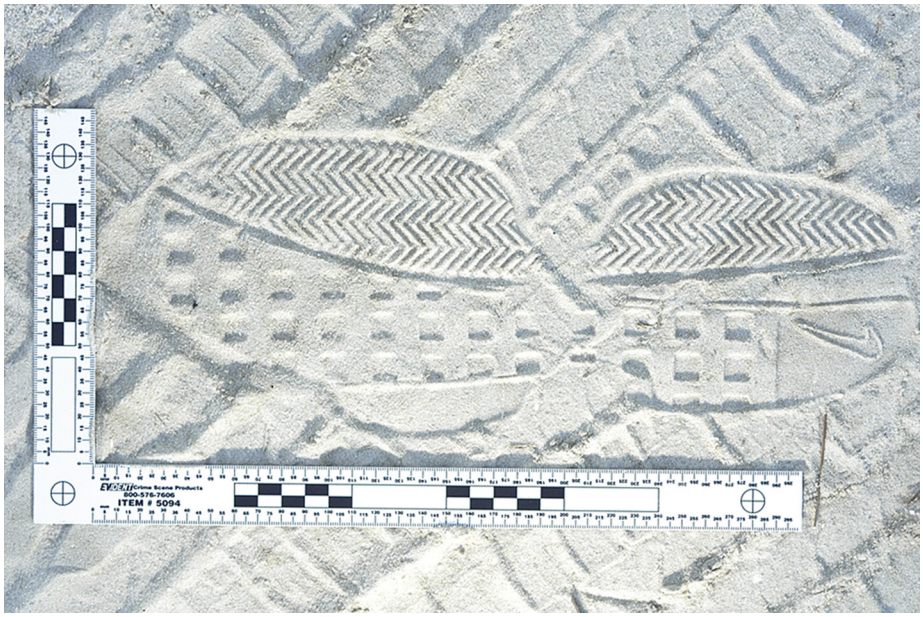


FIGURE C.12 Combination HDR photograph using Photomatix Pro 3 Software changed to black and white. Photo courtesy of King C. Brown and M. Dawn Watkins.



FIGURE C.13 (A) A "proper exposure" as determined by the camera meter. (B) An HDR image combining exposures of +2, +4, −2, and −4. *(Photo courtesy of Marc Hackett, an MPO at the Arlington County Police Department, VA.)*

Fig. C.13A shows a parking garage photographed at the recommended exposure suggested by the camera's meter. With an area in bright sunlight and a large area inside the garage, this exposure cannot possibly provide adequate lighting in such extremes. And, even with an electronic flash, there is still no way to properly expose the area outside and inside the parking garage. Along with this "proper exposure," Marc took a series of brackets at +2, +4, −2, and −4. The HDR image of these five shots is shown in Fig. C.13B. This should be convincing to any skeptics which may be out there. HDR works and helps us look good!

Glossary

A

A centering cone A cone to help a dowel placed into a defect left by a projectile approximate the center of the defect.

Aberrations:

Chromatic Longitudinal and lateral chromatic aberrations. Unless corrected, the different colors of white light will separate and focus at different points. The result is "color fringing," where the edges of objects appear to have strange bands of color.

Spherical The outer part of a lens will bend/refract light differently than the middle or central part, so that all the light does not focus at the same point. The result is soft focus rather than clear, crisp detail.

Coma Off-axis detail will not focus sharply on the film or digital sensor.

Astigmatism Off-axis points in the scene will appear as lines or ovals on the image instead of distinct points.

Curvature of field A subject that is completely flat will be focused sharply in the center of the image, but toward the periphery of the image, the image is "softer" or slightly out of focus.

ABFO scale An "L"-shaped macrophotography scale provided by the American Board of Forensic Odontology (ABFO No. 2)

Acutance The rendering of a sharp edge of a subject as a sharp edge in the photograph.

Air emboli The displacement of air into inappropriate cavities.

Air traffic control (ATC) Depending on location (and ever-evolving regulations), the closest ATC tower may need to be notified of times and locations if a UAS will be operating in NAS.

Aliasing The digital effect of a jagged appearance of diagonal lines, edges of circles, etc. caused by the square nature of most pixels. Also called "jaggies."

Alternate Light Source This refers to any light which has one or more narrow bandpass filters that was developed as a lower cost and more portable exciter light source that could be used instead of a more expensive LASER for fluorescent photography of LASER dye stained latent print evidence.

Ambrotype This direct positive photographic media (when the glass was backed with a dark material) is a collodion light sensitive emulsion coated on a glass plate that produced a slightly lower quality image compared to a Daguerreotype: In spite of the lower quality, it was one of three photographic media that replaced the Daguerreotype because it was cheaper and easier to process. *[Davis, pg. 10, IAI-LEVA Forensic Imaging And Multi-media Glossary, Ver. 7, pg.12]*

Angle of view/field of view Different focal length lenses allow the camera operator to "see" more or less of the real world. Wide-angle lenses allow a wider field of view; telephoto lenses produce a narrower field of view.

Aperture The variable size of the lens opening created by the diameter of the diaphragm.

Aperture priority exposure mode The camera operator selects the aperture/f/stop, and the camera automatically selects the shutter speed to ensure a proper exposure.

ABC (auto backlighting control) Backlighting normally results in an underexposed primary subject. Depressing this button forces the camera to change the exposure setting, usually to a +1½, to have the primary subject properly exposed.

APS-C Digital Sensors A digital sensor smaller than a film negative which is 24mm × 36mm. The APS-C sensors are about 16.7mm × 25.1mm.

Area of origin When multiple individual impact stains are backtracked to a common point/area in 3D space.

Auto exposure bracketing With this feature, some cameras will take three images when the shutter button is depressed just once: a 0, +1, and −1. Some cameras will change the exposure settings automatically but require the shutter to be depressed three times in a row.

AE-L (automatic exposure lock) Depressing this button, and keeping it depressed, will allow the camera operator to lock in one exposure setting and then recompose the image. For example, when taking an exterior overall photo of a building façade that is shady, the camera can be aimed down to eliminate the sky from the field of view. With the shutter priority exposure mode, an exposure for the shade is determined and locked in; then, the camera is recomposed with the sky in the background, and the photo is captured.

AF (auto-focus) By depressing the shutter button halfway, the camera will automatically focus on an item in the center of the viewfinder.

AF-L (automatic focus lock) Depressing this button, and keeping it depressed, will allow the camera operator to lock in one auto-focusing position, then recompose, and take the photograph. For instance, one way to hyperfocal focus with an f/8 is to focus at a point 30′ from the camera. If the scene of interest does not have anything 30′ from the camera to focus on, you could focus on any item 30′ away, lock in the focus by depressing the button and keeping it depressed, then recompose the camera on the scene of interest, and take the picture.

ASA (American Standards Association) The previous method for rating film speeds. ISOs are currently used.

AV (aperture value) (aperture priority exposure mode) The camera operator selects the f/stop, and the camera will automatically select the corresponding shutter speed for a proper exposure.

AWB (automatic white balance) The camera will balance colors on the basis of reflected light coming from a white object in the field of view.

Azimuth The angular distance along the horizon between a point of reference, usually the observer's bearing, and another object.

B

B (bulb) A shutter speed setting that has the shutter remain open as long as the shutter button is depressed or locked open with a remote shutter release cable.

Barrel distortion With a wide-angle lens, the sides of buildings or vertical elements can appear to bow out like the sides of a barrel.

Barrier Filter This is an optical device used to block the passage of light either above or below a specific wavelength of electromagnetic spectrum: The most common use in law enforcement is in fluorescent photography For this purpose a barrier filter is used to block the very bright lower wavelengths of the light used to excite the fluorescence and pass the higher wavelengths that the processed latent print fluoresces at.

Bayer sensor array Most digital sensors have red, green, and blue filters over different pixels in this particular pattern. The camera's computer software then renders a "colored" image, depending on the different values of light coming from all the digital pixels.

Bit The smallest unit of digital memory; a contraction from "binary" and "digit."

Black shield photography For highly reflective surfaces, such as a mirror, a black shield can be used to prevent hot spots in a photograph.

Blooming If each pixel is thought of as a bucket collecting light photons, once one "bucket" is full, the electronic charge caused by additional photons will overflow to surrounding pixels, brightening or tending to overexpose them in the process.

Bounce flash Aiming the electronic flash at a ceiling or side wall to soften the light reaching the primary subject, because the farther light travels to reach a subject, the softer (dimmer) it will be when it gets there.

Bracketing The intentional overexposure and underexposure of succeeding photographs, taken from the same position, to ensure at least one of the images is properly exposed.

Built-in flash Some cameras have flash units built into the camera body that can be activated as desired to provide additional lighting when the scene is dim. Usually not very powerful, they have restricted uses at major crime scenes. They also tend to produce red-eye when used to capture images of people.

Burning Providing additional light to a selected area of an image results in a darker image in that location. Slightly overexposed areas of an image can be improved by burning in those areas. Digital imaging software also allows similar selective darkening to digital images. *See also* Dodging.

Byte Eight bits of memory in a computer.
Kilobyte 1024 bytes (roughly 1000 bytes)
Megabyte 1024^2 (roughly 1 million bytes)
Gigabyte 1024^3 (roughly 1 billion bytes)
Terabyte 1024^4 (roughly 1 trillion bytes)

C

Calotype This was a paper negative process that consisted of a silver chloride light sensitive emulsion coated on paper: It was invented by William Henry Fox Talbot. *[Davis, pp 5–6; and Hedgecoe, pg 22]*.

Carte-de-visite This direct positive photographic media is an albumin light sensitive emulsion coated on paper: This process was cheaper and easier to process as compared to the Daguerreotype, and it was one of three media that replaced the Daguerreotype. *[Davis, pg 10; and Spira, et. al., pp. 55–62]*

Cartridge Unexposed film is stored in a film cartridge until it is processed.

CCD (charge coupled device) A common digital camera sensor type.

CD-R Compact disc-recordable.

CD-ROM Compact disc read-only memory.

CD-RW CD-rewritable.

Center weighted A camera metering method by which an exposure is determined primarily from the light coming from a large oval in the center of the field of view.

Chain of Custody This is a written and/or electronic documentation of the sequence of possession, secure storage, and/or shipping in a sealed container of an item of physical evidence.

Chemiluminescence Luminescence caused by a chemical reagent.

Circle of confusion As focused light comes from the lens to the film plane, it travels in a narrowing cone until it meets at a precise point on the film plane, where the image is judged to be in focus. If the light waves focus before reaching the film plane, they begin diverging and form a circle on the film plane. If the light waves have not yet focused to a point by the time they reach the film plane, they will also form a circle on the film plane. The eye perceives some of these smaller circles to still be in focus. Circles larger than a certain size are perceived by the eye to be out of focus, or "confused." The concept of circles of confusion explains why not only a precise object can be seen to be in focus, but also areas in front of that object and areas behind that object can appear to also be in focus at the same time.

Close-up filters Supplementary filters that can be added to a lens to allow closer focusing and magnification of the subject.

CMOS (complementary metal-oxide semiconductor) A type of digital camera sensor.

CMYK (cyan-magenta-yellow-black) Cyan, magenta, and yellow are the primary subtractive colors. When projected over the same area, they block all light, resulting in black. Many printers also use these dyes to form colors.

Color Correction Filters There are a variety of lighting conditions other than mid-day sun. Daylight color film could be expected to provide accurate colors within the image if, and when, it was exposed by 'normal' mid-day lighting. At those times, accurate colors can be obtained by filtering the lens with color correcting filters.

Compact Flash™ One type of storage media used in digital cameras.

Composite Photographic Superimposition This is a photographic procedure using a photograph of one object and a photographic transparency of a second object so that the transparency can be placed on top of the photograph. Both the photograph and the transparency have to have been photographed from the same perspective and enlarged to the same magnification.

Compression To reduce file sizes so that more files can be stored in the same space, files can be compressed by discarding data with similar colors and contrasts. If not compressed too drastically, it is difficult to notice the difference when viewing an image that has been compressed. Images intended to be used for critical comparisons or examination quality images should never be compressed, because this in effect discards part of the evidence.

Contrast The degree of difference between light areas and dark areas in an image.

Convergence lines When multiple individual impact stains are backtracked to a common point/area on a 2D surface.

Cropping Resizing an image by discarding parts of the edges of the original.

D

Daguerreotype This direct positive photographic media is a silver nitrite light sensitive emulsion coated on a metal plate that is developed with mercury vapor and fixed with a strong salt solution. *[IAI-LEVA Forensic Imaging And Multi-media Glossary, Ver. 7, pg.61, and Davis, pg 5]*

Dedicated flash An electronic flash unit designed to work with a specific camera, where the camera and the flash share information to ensure a proper exposure.

"Degloved" fingerprints During decomposition, the outer layer of skin on the hands (the epidermis) can separate from the hand like a glove.

Depth of field The variable range, from foreground to background, of what appears to be in sharp focus.

Depth of field preview button Most lenses default to their widest aperture until the moment the shutter button is depressed, when they close down to the selected f/stop. Wide apertures allow in more light to make it easier to compose and focus the camera. The widest aperture, however, provides the worst depth of field. If it is the camera operator's desire to maximize the depth of field with a small aperture, this depth-of-field range will not normally be seen in the viewfinder. The depth of field preview button forces the lens to close down to the selected f/stop, so that the depth of field can be seen in the viewfinder.

Depth of field scale This scale is located on many lenses and is frequently shown as pairs of f/stop numbers on either side of the focusing point on the lens. Sometimes they are shown as pairs of colored lines on either side of the focusing point on the lens. They allow the photographer to know the precise depth of field range when either hyperfocal focusing or zone focusing. Unfortunately, many newer lenses do not have this feature.

Diaphragm This is a system of curved, overlapping metal blades that forms the variable lens opening or aperture.

Diffraction Light striking an edge will bend and no longer proceed in a straight line. Light coming through a lens with the smallest apertures is more affected by diffraction, because most of the light forming the image is diffracted light. Diffracted light results in soft focusing and the loss of edge detail. The "cure" to diffraction is to open the aperture at least two f/stops from the smallest aperture of the lens. With a wider aperture, more light comes through the center of the aperture, where it is not affected by diffraction.

DIN (Deutche Industrie Norm) A film speed setting used in Germany.

Drones Unmanned robotic systems, commonly known as *drones*.

Dynamic Range Dynamic range refers to the exposure extremes digital pixels can detect and record.

Dioptric adjustment knob Many camera manufacturers provide a means for individuals to make slight focusing adjustments to the viewfinder. A slide or dial on the right side of the viewfinder allows the individual to adjust the viewfinder to his or her own eyes.

Dodging At times, only parts of an image are a bit underexposed. Dodging allows the darkroom operator to block some of the light from reaching the light-sensitive photographic paper, which lightens the image in those selected parts of the image. Digital imaging software allows the equivalent for digital images. *See also* Burning.

DPI (dots per inch) Ink jet printers work by spraying minute dots of various dyes onto photographic quality paper. Black dots of various sizes suggest differing shades of gray from white to pure black. Dots of varying colors suggest all the colors of the rainbow to the viewer.

DX (data exchange) At one time it was necessary to "tell" the camera what film was loaded into it by setting a dial on the camera to a specific film speed setting. Most film today has a DX "bar code" on the film cartridge, alternating black and silver squares. Newer cameras have sensors in the camera body that can "read" this "bar code" so the camera automatically knows the ISO of the film loaded into it. The code includes the ISO of the film, the number of exposures on the roll of film, and the exposure latitude of the film.

Dye-sensitizing This was the chemical process used to extend the sensitivity of black and white photographic emulsions into the red end of the visible light spectrum. This was the development that led to the panchromatic emulsions.

Dye-sublimation printer A high-end printer in which the color dyes from three colored ribbons are thermally transferred to the printing media. Dye-sub is considered continuous tone printing, forming any one of 16 million colors, with no discrete dots of dyes used to suggest actual colors.

Dynamic range The exposure extremes, from the brightest area of the image to the darkest shadow in the image, digital pixels can detect and record.

E

Exciter Light Source This is usually a narrow band light source that is selected based on what wavelength of the electromagnetic spectrum is absorbed by the fluorescent fingerprint powder, dye stain, or other substance, and results in a fluoresence at a longer wavelength.

Exposure compensation With automatic exposure modes (aperture priority, shutter priority, or program), the exposure compensation dial allows bracketing.

Camera When using any of the automatic exposure modes, you do not bracket by changing either the shutter speed or the aperture of the lens. The exposure compensation dial is set to 1, 2, –1, or –2 as desired.

Flash Bracketing may be achieved by altering the flash output as well. The flash intensity can be altered to 1, 2, –1, and –2 as desired.

Exposure latitude (1) Film has a natural inability to capture details in wide extremes of lighting. With high-contrast scenes, when there are both well-lit areas and areas in deep shadow, only one extreme can record detail. If an exposure for the well-lit area is used, the area in deep shadow will be very underexposed. Fill-flash is used to record details in both extremes. (2) Film that has been either overexposed or underexposed can sometimes be corrected in the wet-chemistry darkroom. Similar corrections can frequently be made to digital images.

Exposure meter Within the camera body, the reflective light meter measures the amount of light entering the camera and recommends a combination of exposure controls to ensure a properly exposed photograph results. The "standard" used by the light meter is an 18% gray card. If more light is detected by the meter, it will suggest an exposure combination that lets in less light, so that an overall 18% gray image results; if less light is detected by the meter, it will suggest an exposure combination that lets in more light, so that an overall 18% gray image results.

Exposure modes There are various methods to determine an overall "proper" exposure.

Manual The photographer sets both the f/stop and shutter speed manually to determine the proper exposure.

Aperture priority The photographer sets the aperture, and the camera will automatically select a corresponding shutter speed to ensure there is a proper exposure.

Shutter priority The photographer sets the shutter speed, and the camera will automatically select a corresponding aperture to ensure there is a proper exposure.

Program The camera selects both the aperture and the shutter speed for a proper exposure.

Extension tubes A lens-like tube inserted between the camera body and the lens that moves the prime lens elements farther from the film plane, resulting in magnification. Extension tubes of different sizes provide different magnifications.

Eyepiece cover Many cameras come with an eyepiece cover, which is used to cover the viewfinder when the photographer will not be holding the camera close to his or her eye as is normal; for instance, when the camera is put on a tripod. If light were to come into the camera through the viewfinder, the light meter in the camera body might add it to the light coming into the front of the lens, which would result in an underexposure.

F

Fair and Accurate Photographic Representation This is a flexible legal standard in the United States that is in effect based on common sense. The basic standard is that the photograph must be accurate enough so that the average person who views the photograph would not be mislead about what the original object depicted in the photograph actually looks like.

Fairfax 1 The call sign of the Fairfax County Police Helicopter.

Federal Aviation Administration (FAA) FAA has jurisdiction over all domestic airspace, which starts just above ground level and extends to 60,000 feet above ground level.

Federal Rule of Evidences (FRE) 901 A witness with appropriate knowledge may *authenticate* an item of evidence through testimony that it is what it is claimed to be.

FFT (fast Fourier transform) Software that allows repetitive patterns in the background to be blurred or eliminated so they do not interfere with the visualization of the primary subject.

Field of view The angle of view of any particular lens. A fish eye lens can view 180° of the scene, whereas a supertelephoto 1200-mm lens takes in only approximately 2° of a scene.

Fill-flash flash technique used to lighten details in deep shadows while other areas are brightly sunlit. Frequently, the fill-flash is set to be 1 stop less intense than the key/main light at the scene.

Film speeds Numbers used to relate different films to their sensitivity to light; 100 ISO film is regarded as a "slow" film, requiring more light for a proper exposure; 1000 ISO film is regarded as a "fast" film, requiring less light for a proper exposure.

Filters Supplemental filters can be used to achieve different photographic effects.

- **UV/Skylight/Haze/A1** These filters are used to filter out UV light and some of the bright light coming from blue skies. Their main purpose, however, is to protect the outer element of the lens. If the lens accidentally contacts a hard object, the inexpensive filter will get scratched, dented, or broken rather than the more expensive lens.
- **IR/87 IR transmitting** Blocks visible light while transmitting IR light for IR effects.
- **18A/UV transmitting** Blocks visible light while transmitting UV light for UV effects.
- **Polarizer** Blocks polarized light that produces reflections on glass and water. Blocks the glare of the sun, resulting in more accurate colors. Blocks sun glare, so that skid marks can better be seen and photographed. Allows the blue color of the sky to be deepened rather than washed out.

***First Person View* (*FPV*)** Enabling the operator to see what the camera sees.

- **ND** Neutral density filters are like sunglasses for the lens, blocking precise amounts of light without affecting the true colors of the scene.
- **Yellow, orange, and red** Filters used with fluorescent photography, paired with UV, blue, and green light, respectively.

Flare If the sun is in front of the photographer, direct sunlight can enter the lens, bounce around the various lens elements, and result in unwanted multicolored geometric artifacts in the photograph.

Flash exposure modes When the electronic flash is used, there are different means to achieve a proper exposure.

- **Manual mode** the flash goes off, exposures are determined by altering the aperture of the lens or the intensity of the flash for the distance of the flash to the subject.
- **Automatic mode** A sensor on the flash reads the amount of reflected light to decrease or prolong the flash duration for a proper exposure.
- **Dedicated mode** The light meter in the camera body reads the reflected light coming in through the lens (TTL) to decrease or prolong the flash duration for a proper exposure.
- **Flash bracket** Usually a mount to affix the flash to, which is also connected to the camera, so that the flash does not have to be held separately. This frees up one hand to make focusing and focal length adjustments. It also positions the flash farther from the lens, reducing the chance of red-eye when taking photographs of people.
- **Flash diffuser** Direct flash is very harsh, and with many medium-range or close-up subjects, softening the direct flash results in more pleasing images. Diffusers range from multifaceted plastic clip-ons that reflect the flash wider than normal that soften the light, to milk-glass–type covers that enclose the flash head, to bounce surfaces that diffuse the flash beam wider than normal, to handkerchiefs that cover the flash head.

Flip-up flash Many cameras have built-in flashes that are not visible when not in use. They will flip up when the light is dim and supplemental lighting is needed.

F-number Like f/8, these numbers relate the size of the aperture opening to the focal length of the lens used. The equation, FLL/F-Number = DoD applies, where FLL is the focal length of the lens, and DoD is the diameter of the diaphragm. If the FFL is 50 mm and an f/8 is set on the camera, the DoD is: 50/8 = 6.25 mm.

Focal length The distance between the optical center of the lens and the film plane, when the lens is focused on infinity.

Focal Length Multiplier Medium priced and less expensive digital SLR cameras use digital sensors that are smaller than a film's negative. The effect is that the smaller digital sensor captures less detail than the film negative would have. Another way to look at this is that the smaller digital sensor produces a 'crop' of the full-size image. This 'crop' can be thought of as a reduced field of view, or an image captured by a longer focal length lens. Therefore, a 50mm lens used on a digital camera with a 1.5 focal length multiplier, captures what a 75mm lens would have captured had the camera been a film camera or a digital camera with a film-sized digital sensor.

Focal-plane shutter SLR cameras have the shutter curtains immediately in front of the film. Other types of cameras may have leaf shutters located in the lens itself, rather than in the camera body.

Focus Setting the camera so that light coming in through the lens converges to a precise point on the film plane.

Auto-focus the shutter button is depressed half way down, the camera will automatically focus on the object appearing in the middle of the viewfinder or at the position of another sensor selected by the photographer.

Manual focus The photographer has to manually rotate the focus ring on the lens to focus the camera.

Forensic Anthropology Center (aka "body farm") A facility at the University of Tennessee where bodies donated for scientific research can be placed in similar circumstances as bodies located in criminal investigations, so the decomposition rate can be studied with controlled variables to help determine the postmortem interval.

FRE 403 The court may exclude relevant evidence if its probative value is substantially outweighed by a danger of one or more of the following unfair prejudice, confusing the issues, misleading the jury, undue delay, wasting time, or needlessly presenting cumulative evidence.

Front-curtain sync With a dedicated flash, specifically designed to work with a specific camera, the flash can fire either once the shutter first completely opens (front-curtain sync) or just before the rear curtain begins to close (rear-curtain sync). This allows creative effects, such as motion streaks in front of or behind a moving object.

Funduscopic camera The retina can be photographed directly as the pupil is used as both an entrance and exit for the **fundus camera's** illuminating and imaging light rays.

G

Gel or Gelatin Filter This usually refers to the old Kodak Wratten filters that were made by depositing a gelatin coating on a flexible base. The gelatin layer would contain the dye or dyes for the filter. For camera lenses, these filters usually came in 2″ × 2″, 3″ × 3″, or 4″ × 4″ size. A filter holder would be attached to the front of the lens, unless the lens has a slot on the rear in which case the gelatin filter would be cut down to fit this slot such as for a fisheye lens.

Ghost Photographs In the mid to late 1800's these fake photographs of the ghosts of recently deceased family members were made to fraudulently obtain money from rich families. The process of faking the photographs was very easy and looked very believable. The fake photograph would consist of a normal exposure of the surviving family members combined with an underexposed image a person who was similar in appearance to the deceased family member. The second underexposed image of the so-called ghost can be made on the same negative in the camera, or it can be printed in the darkroom from a second negative.

Gimbal A support system that facilitates XYZ axis movement of a camera or other imaging device.

Glass Filter This refers to three types of construction and are usually mounted in a threaded filter ring. The most common glass filters have the dye incorporated directly into the glass itself and they usually have an optical coating to protect the filter. For scientific applications, there are several glass filters that are made by depositing one or more thin layers to control the optical properties of the filter. The third type of construction, which is very rare involves cementing the optical parts of the filter together. This was done in one of two ways. In the past there were a few gelatin wratten filters in which the gelatin filter was cemented between two pieces of optically flat clear glass. For a photographic technique that always requires the use of the same two filters stacked together, there is sometimes a custom filter available that consists of these two filters cemented together and mounted in a threaded filter ring. Compared to stacked filters this usually results in a reduction of the internal reflections.

GN (guide number) An indication of the relative power of a particular flash unit.

Graininess When film images are enlarged too much, the individual silver halide crystals making up the image separate and become visible as discrete specks. The degraded image is said to be "grainy."

Gray card The 18% gray card is the standard used by camera reflective light meters to determine the proper exposure settings on the camera. If a particular scene is not reflecting this "norm," a proper exposure can be determined by aiming the camera at an 18% gray card and taking a meter reading of it.

H

High Dynamic Range

Histogram A bar graph depicting the relative quantity of dark, medium gray, and light portions of an image to give the photographer a quick assessment of the exposure, contrast, and dynamic range of an image.

History As digital images are "processed" to improve the visibility of the main subject matter, the photographer should keep notes about both the type of image processing used and the amount of the processing applied to the image. Some software will automatically record these data and link them to the image.

Hot-shoe Many cameras have a mount on the camera body where the electronic flash will attach so that sensors on the mount and flash will electronically link both.

Hyperfocal distance When one is hyperfocal focusing to maximize the depth of field in an exterior overall photograph, this is the precise distance the distance scale is aligned with. For example, when hyperfocal focusing with an f/8, resulting in a depth of field range of 15′ to infinity, the hyperfocal distance is –30′.

Hyperfocal focusing This is the method to maximize the depth of field when infinity must also be in-focus. Take a meter reading to determine the f/stop required for the exposure, then align the infinity symbol on the focusing ring with the corresponding f/stop on the depth-of-field scale.

I

Image stabilization Many newer lenses feature what is referred to as either Vibration Reduction (VR) or Image Stabilization (IS). To achieve this effect, either lens elements or the digital sensor itself have the ability to gyroscopically move as the camera detects movement, counteracting the camera 'shake.' Vibration Reduction and Image Stabilization systems can usually guarantee the absence of blur when using shutter speeds at least 2-stops slower than 'normal.'

Impact pattern When blood strikes various surfaces, the velocity of the blood and the texture of the substrate may affect the stain pattern.

Incident light meter This is a hand-held light meter able to determine the exposure settings required for a proper exposure. This meter is positioned at the location of the subject to be photographed, reading the light falling on the subject.

Inclinometers Useful for determining the vertical angle of a trajectory.

Infrared Visible light falls between 400 and 700 nanometers on the electromagnetic spectrum. Infrared light used in photography is between 700 and 1100 nanometers.

IR This is an abbreviation for infrared, which is above the visible light part of the electromagnetic spectrum. The usefull range for photography is approximately 700nm to 1,000nm.

IR Photograph This is a photograph taken on infrared film, or with a digital camera that has been modified to allow for infrared radiation to reach the sensor. A reflected IR photograph is made by radiation from an infrared light source that is reflected from the object being photographed. An Infrared Luminescent photograph is usually excited by a monochrome or narrow wavelength light source with a primary wavelength of approximately 514nm which can excite an infrared luminescence. For infrared photographs, an infrared bandpass filter is usually used over the lens.

Interpolation A process that enlarges an image beyond its original size by adding extra pixels between the original pixels that are separated to fit a larger area.

Inverse square law Light diminishes by the inverse square of the distance traveled. As the distance light travels doubles, its intensity is quartered; 2× becomes $(1/2)^2$, which is 1/4th. As the distance light travels is halved, its intensity is quadrupled; ×/2 becomes $(2)^2$, which is 4.

ISO film speed settings International Standards Organization. Previously, film speeds had been rated by ASA (American Standards Association) numbers.

Isosceles Triangle Point of View The photographer will be at one point of the triangle, and the evidence and the fixed feature of the scene will be at the end of the two equal length sides of the triangle.

J

Jaggies These are the visible digital "stair-steps" of diagonal lines or edges. Also referred to as "aliasing," this is more pronounced with fewer larger pixels to make up the image or when the digital image is enlarged too much.

JPEG (joint photographic expert group) A "lossy" type of storage of a digital file. Similar color and contrast details can be permanently discarded to reduce the file size, allowing more images to be stored in the same space.

K

Kilobyte A data unit of 1024 bytes.

L

Langer's lines Stab wounds will remain narrow or gape depending on the underlying musculature they are over. If the underlying muscle tissue runs parallel to the stab wound, the wound tends to remain in the shape of the weapon; if the underlying muscle tissue runs perpendicular to the stab wound, the wound will tend to pull wider and narrower than the shape of the blade.

LCD Liquid crystal display.

LED panel Light-emitting diode.

Lenses

- **Close-up lens/macro lens** Designed to produce magnifications allowing small items the size of a fingerprint to fill the frame.
- **Normal lens** A 50-mm lens for a 35-mm SLR camera system. Normally, a focal length equivalent to the diagonal of the film.
- **Telephoto lens** A lens larger than 50 mm.
- **Wide-angle lens** A lens smaller than 50 mm.
- **Zoom lens** A lens that can be set to a variety of focal lengths.
- **Achromatic lens** A lens corrected for chromatic aberration.
- **Anastigmat** A lens corrected for the aberration "astigmatism."
- **Aplanat** A lens corrected for spherical aberration.
- **Apochromatic** A lens that can focus all colors of visible light at the exact same location on the film plane.
- **Aspherical lens** Reduces spherical aberrations.

Lens shade/hood An extension of the end of the lens designed to block direct sunlight entering the lens creating flare.

Lividity Discoloration of the skin from the settling of blood due to gravity.

Lossless compression A compression format that reduces the file size without permanently discarding data, like TIFFs.

Lossy compression A compression format that permanently discards data to achieve smaller file sizes, like JPEGs.

LZW An alternative to the JPEG compression format is the LZW (for the developers, Lempel-ZIV-Welch) TIFF compression format. LZW TIFFs are considered a **"lossless"** file format. LZW TIFF compressions reorder the digital data into a smaller file size without deleting any pixels at all.

M

Macro lens A lens designed to provide magnifications of up to 1:1, where the true size of the object is captured life size on the negative.

Manual exposure mode The photographer sets both the shutter speed and the aperture manually to achieve a proper exposure.

Manual flash When the flash goes off, exposures are determined by altering the aperture of the lens or the intensity of the flash for the distance of the flash to the subject.

Manual focus The focus ring of the lens is manually adjusted to establish focus.

Marbling Decomposition makes the venous system more obvious.

Megabyte This is usually 1,048,576 bytes; however, it is sometimes interpreted as 1 million bytes.

Metadata Digital cameras often record more than just the digital image. With a digital image this can include, but is not limited to, exposure settings, information about the camera used, and a record of in-camera processing performed on the image.

Metering Cameras have various methods to determine the proper exposure of an image.

- **Averaging/center-weighted** The camera will evaluate the light coming from a large oval in the center of the field of view.
- **Spot** The camera will only register the light coming from a small circle in the center of the viewfinder.
- **Matrix** The viewfinder is segmented into various geometric designs, and then the light in each segment is evaluated and weighed on the basis of the computer software in the camera. This usually provides the most precise exposure determination.

Mid-roll change/rewind Some cameras will allow a roll of film to be rewound when only partially used. To enable the film to be reloaded, the film leader strip is not completely rewound all the way into the film canister. Then, once reloaded, the film can be advanced to the frame last used, and then additional images can be captured on it.

Mirror lock-up When SLR cameras capture an image, the mirror in the camera body swings up to allow the light entering the camera through the lens to strike the film. This movement generates a small amount of camera shake. When the camera is on a tripod, some cameras allow the mirror to be locked-up before the shutter is depressed. This reduces camera vibrations and potential blur.

"Modesty" towel A towel placed over a deceased's face or genitals during photography.

Monopod/unipod A camera support with a single leg as opposed to the three legs of a tripod. Helps steady the camera so that slower shutter speeds can be used, or longer telephoto lenses can be used.

Motor drive Some cameras will automatically advance the film after each shot. Other cameras will have to be advanced by manually cranking a lever between each shot.

Muzzle imprint When the end of the barrel is against the skin when the weapon is fired, the shape of the muzzle can bruise the skin.

N

Nanometer One billionth of a meter. Light waves in the visible light range of the electromagnetic spectrum are measured in nanometers. This is the distance between light wave peaks

National Institute of Standards and Technology (NIST) and Organization of Scientific Areas Committees (OSAC) These have replaced the previous SWGs.

Natural perspective Where the camera is at the photographer's eye height.

Navigation Controller The "brain" of an unmanned system is its controller.

NEF Nikon electronic format.

Negative film Normal print film, where tones are reversed so that highlights appear dark and shadows appear light on the developed negatives.

Neutral density filter Sunglasses for the camera. These filters uniformly reduce the light coming in to the camera without altering relative colors.

NiCd Nickel cadmium camera battery.

NiMH Nickel-metal hydride camera battery.

Noise Digital image degradation seen as monochromatic grain and/or as colored waves. It can also appear as random groups of red, green, or blue pixels.

Normal lens For a 35-mm SLR camera, a 50-mm lens. Also, thought of as the diagonal of the film used.

Normal room Manual flash exposure calculations presume the flash is operated in a "normal room." This is an average-sized living room or bedroom with white ceilings about 8′ to 9′ high, and light-colored walls. Such ceilings and walls reflect some light toward the subject being photographed. Manual flash exposure calculations presume this additional light is available.

O

Oblique flash Flash used at different angles, usually to produce side-lighting shadows.

Ophthalmic pathology A reference to damage or disease to the eyes.

Optical Watermark This is usually a translucent image of a logo or name that is superimposed over a photograph. With photographs this has been used by portrait studies to reduce copyright infringement. Commercial television stations use this to identify the station and to reduce copyright infringement. Because it does alter the photograph, it has been rejected by the forensic science community for authentication purposes.

Orthochromatic Film This refers to a black and white film that is sensitive to violet through green visible light, with no sensitivity to the red end of the visible light spectrum.

OTF (off-the-film metering) Sometimes called dedicated flash or TTL flash. Light reflected off the subject is reflected back to the camera, comes through the lens, and reflects off the film where the light meter is located.

Out of focus An image, or a part of an image, is perceived to be out of focus when the light striking the film forms a circle larger than the circle of confusion perceived by the eye to be in-focus.

Overexposure When the image is lit with more light than normal.

P

Painting with light A technique to light a large dim scene with multiple flashes while the camera has the shutter locked open so the multiple flashes light a single negative.

Panchromatic Film This refers to a black and white film that is sensitive to all the visible light spectrum.

Panning Moving the camera to track with a moving subject to reduce the blurriness of the image.

PC cord A coiled electronic connection between the camera body and a flash unit used off camera. Also called a sync cord, "PC" is an acronym for Prontor-Compur, the two European shutter makers who, long ago, devised a system that allowed a cable from a studio electronic flash unit to synchronize with a camera shutter.

Penetrations A projectile striking the surface of an object and causing an entry defect but without exiting.

Pentaprism A system of internal mirrors designed to allow the photographer to see the same image coming in through the lens while looking into the viewfinder.

Perforations The term perforation refers to a projectile that passes through an article.

Photogrammetry The method by which accurate measurements may be extrapolated from photographs.

Photogrammetry The art, science, and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena. In forensic applications, this is the mathematically based scientific principles used to extract dimensional information from images, such as the height of subjects depicted in surveillance images and accident scene reconstruction. *[IAI-LEVA Forensic Imaging And Multi-media Glossary, Ver. 7, pg. 185]*.

Picture element Digital camera sensors are made up of individual picture elements, also known as pixels.

Pincushion distortion The lens distortion that shows linear elements at the periphery of an image that appear to be bending in to the center of the image. Usually most manifest with larger telephoto lenses.

Pixel A shortened version of "picture element."

Pixelization When digital images are enlarged too much, the individual pixels making up the image become large enough to see. The image looks boxy, without smooth transitions.

Plumb line A string with a weight at the end to help determine vertical lines.

Plumbs A string with a weight at the end to help determine vertical lines.

Polarizing filter Blocks polarized light that produces reflections on glass and water. Blocks the glare of the sun, resulting in more accurate colors. Blocks sun glare, so that skid marks can better be seen and photographed. Allows the blue color of the sky to be deepened rather than washed out.

PPI Pixels per inch.

Predictive auto-focus When photographing moving subjects, some cameras enable the camera to predict the location of the moving subject and focus where the object will be when the shutter is fully depressed, rather than where it was then the shutter was depressed only halfway.

Program exposure mode The camera will select both the shutter speed and the aperture to ensure a proper exposure.

Pro-sumer This is a vague term that refers to camera equipment that is used by both advanced amateurs and professional photographers.

Pulling Rating a film at a slower ISO rating than it really is to increase color saturation and contrast. For instance, using a 400 ISO film but setting the camera to ISO 320.

Pushing Rating a film at a faster ISO rating than it really is to extract detail from an underexposed image. For example, using a 3200 ISO film but considering it as ISO 12800, 2 stops faster.

Q

QVTR This refers to an apple quicktime file that is created by stitching together a series of overlapping photographs to create an interactive image which you can move to view a 360 degree image of a scene and can be linked to individual still photographs and other QVTR files. This can be used to give officers at the scene, witnesses, and the jury a virtual tour of the scene. Some automatic systems also have a measurement and crime scene diagramming capability

R

RAM Random access memory.

RAW A RAW (not an acronym for anything) file, to be precise, is not yet an image: it is an 'unprocessed' file. The RAW file will have to be brought in to a RAW converter program, where decisions will then have to be made on everything about the image. The RAW format gives the photographer the most control over what the finalized image will look like.

Raw file format RAW files store the unprocessed image data. Most digital cameras set to capture images as TIFFs or JPEGs use in-camera adjustments to set various image variables: white balance, exposure value, color values, contrast, brightness, and sharpness. RAW image files must be processed with special software before they can be viewed or printed. The advantage is that you have the ability to alter the image variables as you see fit before you convert these data into the standard JPEG or TIFF format.

Rear-curtain sync Cameras with dedicated flash units can be adjusted to have the flash fire just before the rear-curtain begins to close. Usually the flash fires immediately after the front curtain has opened all the way. This is used for creative photography where streaking is desired in front of or behind moving objects.

Reciprocity failure Many different combinations of shutter speeds and apertures will result in the same exposure. Increasing one variable while decreasing the other results in the same exposure. When exposures are either too long or too short, this concept of reciprocity breaks down. Usually exposures longer than 1 second or shorter than 1/1000th of a second will suffer from reciprocity failure. Either extreme results in underexposures.

Reciprocity law Many different combinations of shutter speeds and apertures will result in the same exposure. Increasing one variable while decreasing the other results in the same exposure.

Red-eye When the flash is used close to the lens, the light will bounce off the red blood vessels at the back of the eye, and the result will be subjects with red eyes.

Reflective light meter The light meter in the camera body is a reflective light meter; it reacts to the light reflecting off the subject coming into the camera through the lens.

Refraction As light moves from one medium to another, it bends. Refraction also is the cause of underwater objects appearing closer to the camera than they really are.

Remote flash cord An advancement to the original PC cord, this allows the camera body and the flash to interact in additional ways, besides firing the flash when the shutter has opened. The flash will know what ISO film has been loaded into the camera body. The flash will alter its flash throw as different focal lengths are selected on a zoom lens. Changes to the intensity of the flash can be set on the camera body.

Re-sampling Changing the resolution of an image either by removing pixels (lowering resolution/compressing the image) or adding them by interpolation (increasing the printable size of the image).

Resizing Changing the size of an image without altering the resolution. Increasing the size will lead to a decrease in image quality.

Resolution The capability of a photographic reproduction to distinctly record two separate but adjacent elements of an image. In still photography resolution is frequently measured in line pairs for film and pixels per inch for digital files.

Ring flash A flash unit encircling a lens emitting light onto all sides of a small object. A soft light producing almost no shadows.

Roadmapping A photo documentation method for bloodstain patterns (Wolson, 1997).

ROM Read-only memory.

Round reinforcement labels Used to mark the locations of very small spatter stains.

Rotation If a digital image appears slightly tilted, it is possible to turn the image on one of its axes, correcting the composition error.

Rule of thirds To maximize the depth of field when focusing on medium-sized areas, compose the shot, make a mental note of the distance between the bottom and top of the viewfinder. Focus at a distance point midway between the top and bottom of the viewfinder. Geometrically, this is approximately the same as focusing one third of the way into the length of the scene.

S

Scientific Working Group on Digital Evidence (SWGDE) A group of professionals tasked with making guidelines for analyzing digital evidence.

Scientific Working Group on Imaging Technologies (SWGIT) A group of professionals tasked with making guidelines for crime scene photography.

Self-timer/delayed shutter times Many newer cameras allow the camera to set the shutter to trip either 2 seconds or 10 seconds after depressing the shutter button. This allows the camera on a tripod to settle down after the shutter button is depressed, reducing the chance of blur from camera shake.

Shutter This controls the amount of time light that is allowed to reach the film.

Shutter release cable/remote shutter cable When the camera is mounted on a tripod, the shutter button should not be depressed manually; doing so will induce movement to the camera and blur the image as a result. These cables dampen this movement.

Shutter priority The photographer sets the shutter speed desired, and the camera automatically sets the corresponding aperture to provide a proper exposure.

Shutter speed The time the shutter is allowed to remain open, usually expressed in fractions of a second. Most cameras allow some shutter speeds in full seconds also.

Silver halide crystals This is the light-sensitive part of common photographic films; the usual light-sensitive chemicals are silver chloride, silver bromide, and silver iodide.

Single-lens-reflex (SLR) camera This is a camera in which a system of mirrors and prisms shows the user the image in the viewfinder exactly the way the lens captures the image.

Skylight filter A filter designed to filter out some of the intense light from the sky so that the sky does not appear overexposed. One of several filters commonly used to protect the outer element of the lens.

Slow film ISO speeds of 100 or less.

Slow sync Very slow shutter speeds used with a flash, less than 1/60th of a second. If the remote shutter cord broke or was missing while at a nighttime scene, the flash could be fired manually when a 2-second shutter speed was set for the camera on a tripod, allowing the flash to be fired manually while the shutter was open.

SmartMedia™ One of many types of digital memory cards used in some cameras.

Spirit Photographs See Ghost Photographs.

Spot metering The camera will only register the light coming from a small circle in the center of the viewfinder.

Stair stepping Also called aliasing or jaggies.

Stellate entry wound Large gaping wounds when a weapon is fired with the muzzle against the skin over bone. Gases from the barrel accumulate between the skin and the scull and tend to blow back toward the weapon, tearing the skin in large star-shaped (stellate) tears.

Stippling or tattooing This "tattooing" is different from the "tattooing" known as artistic decoration of the skin. In relation to stippling, it means the presence of GSR on clothing or skin.

Stokes' Law This is the basic theory on which all fluorescent photography is based. The theory is very simple. The fluorescence that is created by the absorption of the exciter wavelength of light with be at a wavelength that is longer than the wavelength of the exciter light. The practical impact is that the barrier filter needs to block all wavelengths below the wavelength of the exciter light source.

Stop down Normally meaning a change from a wider aperture to a smaller aperture.

Supplementary lenses/close-up filters A set of three filters that can be used separately or in combination, which produce varying amounts of magnification. Usually designated as a +1, +2, and +4.

"Sweet spot" apertures F/11 is an f-stop to consider for these types of photographs to minimize lens aberrations and diffraction.

Sync cord A coiled electrical connection between the camera body and the detached flash unit, allowing the flash to fire when the shutter is open.

Synchronize/sync shutter speed The shutter speed of a particular camera that ensures the flash fires when the shutter is completely open. Sometimes 1/60th, 1/90th, 1/125th, or 1/250th of a second.

Front curtain sync Dedicated flash units allow the flash to fire immediately after the front curtain has completely opened. This is the default for most flash units.

Rear curtain sync Dedicated flash units sometimes allow the flash to fire just before the rear curtain begins to close. A creative photography option, allowing streaking in front of or behind moving objects.

T

T ("time" SS setting) The shutter opens when the shutter button is first depressed and closes the second time it is depressed, allowing for various timed exposures.

Tagged image file format TIFF file format. An uncompressed image file format that is lossless.

Telecine Machine This is a machine used to convert movie film to video. *[IAI-LEVA Forensic Imaging And Multi-media Glossary, Ver. 7, pg. 240]*.

Teleconverter A supplemental lens used with telephoto lens to make them act like longer telephoto lenses. Frequently available in 1.4× and 2× powers, they would make a 100-mm lens act like either a 140-mm or 200-mm lens, respectively. Usually a less expensive alternative to buying a longer focal length lens.

Telephoto lens For a 35-mm SLR camera, a lens with a longer focal length than 50 mm.

The grid method With this method, the surface containing the patterns or stains is gridded into 2′ × 2′ squares, or any size squares depending on the size of the surface and the density of distinct patterns or stains.

Through-the-lens metering (TTL) TTL metering usually refers to a dedicated flash unit that has its flash duration determined by the reflected light from the scene being metered by the light meter in the camera body.

TIFF Tagged image file format.

Tintype This is also called a ferrotype. It is a collodion emulsion coated on metal. This was one of three processes cheaper and easier to process as compared to the Daguerreotype process. Because of the cost even high end portrait studios had to convert from the higher quality Daguerreotype because the customer in general was more interested in how much they had to pay for the portraits. *[Davis, pg 10]*.

Tripod A three-legged camera support enabling slower shutter speeds to be used without blur.

TTL flash TTL flash usually refers to a dedicated flash unit that has its flash duration determined by the reflected light from the scene coming through the lens (TTL) being metered by the light meter in the camera body.

Tv (time value) (shutter priority mode) The photographer selects the shutter speed as desired, and the camera will automatically select the aperture to provide a proper exposure.

U

Ultraviolet Light energy of the electromagnetic spectrum, invisible to the eye, in the 100-nm to 400-nm frequency.

Underexposure An image darker than normal, or what is considered properly exposed.

Unipod A camera support with a single leg as opposed to the three legs of a tripod. Helps steady the camera so that slower shutter speeds or longer telephoto lenses can be used.

Unsharp mask An image-sharpening filter available with image processing software.

USB Universal serial bus.

UV filter Most UV filters block UV light to help prevent overexposures when there are large amounts of sky in the field of view. UV filters are also used to protect the outer element of the lens. The 18A filter, in contrast, transmits only UV light while blocking all visible light.

V

Variable power Many flash units allow a manual flash unit to be used in varying increments, from 1/2 power to 1/128th power, to enable the flash to be used at closer distances to the subject.

Vibration Reduction Many newer lenses feature what is referred to as either Vibration Reduction (VR) or Image Stabilization (IS). To achieve this effect, either lens elements or the digital sensor itself have the ability to gyroscopically move as the camera detects movement, counteracting the camera 'shake.' Vibration Reduction and Image Stabilization systems can usually guarantee the absence of blur when using shutter speeds at least 2-stops slower than 'normal.'

Viewfinder The opening in the rear of the camera allowing the photographer to compose and focus the photograph. In 35-mm SLR cameras, a series of mirrors allows the photographer to view the subject exactly the same way the film or digital sensor will record it.

W

Wagon Wheel Ellipse When a circular object is viewed from the side, instead of from above, it appears elliptical. Wagon wheel spokes demonstrate the "distortions" to the perceived spoke lengths when viewed from the side.

Walking the laser Physically moving solid flat surfaces along the beam's path while a camera captures the action.

Wet Plate Process This is a photographic process in which a glass plate was coated with a collodion mixture, then sensitized with silver nitrate, exposed, and developed while the collodion was still wet. It was popular from the 1850s until the introduction of the gelatin dry plate in the 1880s. *[IAI-LEVA Forensic Imaging And Multi-media Glossary, Ver. 7, pg. 240]*.

White balance settings Digital cameras enable the camera to be adjusted for the ambient lighting to ensure white objects are truly white and improper color tints do not adversely affect the image. When a white subject is captured as white, other colors are also captured faithfully.

Auto If the scene has a white surface within view, the camera will automatically adjust color levels to ensure it is truly white in the image.

Sun When sunlight is the primary lighting, whites will be recorded as truly white.

Flash When electronic flash is the primary lighting, whites will be recorded as truly white.

Shade When shade is the primary lighting, whites will be recorded as truly white. Otherwise there is a tendency for a bluish tint.

Tungsten When household light bulbs with tungsten filaments are the primary lighting, whites will be recorded as truly white. Otherwise there is a tendency for a yellowish tint.

Fluorescent When fluorescent lighting is the primary lighting, whites will be recorded as truly white. Otherwise there is a tendency for a greenish tint.

Wide-angle distortion Wide-angle lenses tend to elongate the perceived foreground to background distance.

Wide-angle lens With a 35-mm SLR camera, a wide-angle lens is one with a focal length smaller than 50 mm.

2015 World Police and Fire Games This is the second largest athletic event in the world, next to the Olympics.

X

X sync This is an older flash shutter speed that causes an electronic flash to fire in synchronization with the shutter. Some older cameras had an "X" designation on the shutter speed dial to more easily set the shutter speed whenever using flash.

Z

Zero-edge protractors 180-degree devices numbered in 10-degree increments and single-degree indication markings.

Zone focusing A focusing technique to ensure a particular area of the scene is included in the camera's depth-of-field range. If the lens has a depth-of-field scale, the rear distance needing to be in focus is aligned with the f/stop on the depth-of-field scale required for a proper exposure. Comparing the depth-of-field scale to the distance scale shows the resulting depth-of-field range.

Zoom lens A lens with multiple focal lengths.

1:1 Usually, a magnification ratio ensuring the item of evidence is life-sized on the negative. In this case, a single digit fingerprint, or an object the size of a nickel, will fill the frame of the viewfinder. Other times, it is an indication that a print be created so the object is life-sized in the print.

35-mm film Film that is 35 mm in width, designed to be used with 35-mm cameras.

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